MODULARITY - THE NEXT STEP IN THE EVOLUTION OF THE ARMORED ENGINEER BATTALION

A MONOGRAPH
BY
Major Robert A. Sinkler
Corps of Engineers

School of Advanced Military Studies
United States Army Command and General Staff College
Fort Leavenworth, Kansas

First Term AY 96-97

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	6 December 1996	Monograph, 15 Jul 96 - 6 Dec 96

4. TITLE AND SUBTITLE

Modularity - The Next Step in the Evolution of the Armored Engineer Battalion

5. FUNDING NUMBERS

6. AUTHOR(S)

Major Robert A. Sinkler, U.S. Army

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

SCHOOL OF ADVANCED MILITARY STUDIES
ATTN: ATZL-SWV
Fort Leavenworth, Kansas 66027-6900
COM (913) 684-3437 AUTOVON 552-3437

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

"Approved for public release; distribution is unlimited."

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This monograph proposes an alternative design concept for the future divisional Armored Engineer Battalion. The research hypothesis is that an Armored Engineer Battalion organized around core battlefield missions would be more effective in supporting the armored or mechanized brigade in full-dimensional operations than the Current Armored Engineer Battalion. The two Armored Engineer Battalion organizations were evaluated to determine which organizational structure would be most effective on the twenty-first century battlefield. The two organizations were analyzed in terms of organizational friction, tempo, and battlespace in an operational scenario. The ability of the two battalions to conduct battle-focused training was also analyzed.

Additionally, this monograph examines the evolutionary development of the Armored Combat Engineer Battalion, defines the term armored combat engineer, identifies current organizational structures common in today's armored combat engineer organizations, describes future warfare, and identifies future trends in military organizational design.

The principle findings from the analysis and evaluation indicates that an Armored Engineer Battalion organized around core battlefield missions will be more effective on the twenty-first century battlefield than the Current Armored Engineer Battalion. The findings fully support the research hypothesis.

14. SUBJECT TERMS

ENGINEER COMBAT ENGINEER

ARMORED ENGINEER BATTLESPACE FORCE XXI MODULARITY

15. NUMBER OF PAGES

86

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

ABSTRACT

MODULARITY - THE NEXT STEP IN THE EVOLUTION OF THE ARMORED ENGINEER BATTALION by Major Robert A. Sinkler, USA, 86 pages.

This monograph proposes an alternative design concept for the future divisional Armored Engineer Battalion. The research hypothesis is that an Armored Engineer Battalion organized around core battlefield missions would be more effective in supporting the armored or mechanized brigade in full-dimensional operations than the Current Armored Engineer Battalion. The two Armored Engineer Battalion organizations were evaluated to determine which organizational structure would be most effective on the twenty-first century battlefield. The two organizations were analyzed in terms of organizational friction, tempo, and battlespace in an operational scenario. The ability of the two battalions to conduct battle-focused training was also analyzed.

Additionally, this monograph examines the evolutionary development of the Armored Combat Engineer Battalion, defines the term armored combat engineer, identifies current organizational structures common in today's armored combat engineer organizations, describes future warfare, and identifies future trends in military organizational design.

The principle findings from the analysis and evaluation indicates that an Armored Engineer Battalion organized around core battlefield missions will be more effective on the twenty-first century battlefield than the Current Armored Engineer Battalion. The findings fully support the research hypothesis.

SCHOOL OF ADVANCED MILITARY STUDIES

MONOGRAPH APPROVAL

Major Robert A. Sinkler

Title of Monograph: *Modularity-The Next Step in the Evolution of the Armored Engineer Battalion*

Approved by:

Clarence Edward Taylor
Lieutenant Colonel Clarence E. Taylor, MMAS — Monograph Director

Danny M. Davis
Colonel Danny M. Davis, MA, MMAS — Director, School of Advanced Military Studies

Philip J. Brookes
Philip J. Brookes, Ph.D. — Director, Graduate Degree Program

Accepted this 6th Day of December 1996

Modularity -
The Next Step in the Evolution
of the Armored Engineer Battalion

A Monograph
by

Major Robert A. Sinkler

School of Advanced Military Studies
United States Army Command and General Staff College
Fort Leavenworth, Kansas

First Term AY 96-97

ABSTRACT

MODULARITY - THE NEXT STEP IN THE EVOLUTION OF THE ARMORED ENGINEER BATTALION by Major Robert A. Sinkler, USA, 86 pages.

This monograph proposes an alternative design concept for the future divisional Armored Engineer Battalion. The research hypothesis is that an Armored Engineer Battalion organized around core battlefield missions would be more effective in supporting the armored or mechanized brigade in full-dimensional operations than the Current Armored Engineer Battalion. The two Armored Engineer Battalion organizations were evaluated to determine which organizational structure would be most effective on the twenty-first century battlefield. The two organizations were analyzed in terms of organizational friction, tempo, and battlespace in an operational scenario. The ability of the two battalions to conduct battle-focused training was also analyzed.

Additionally, this monograph examines the evolutionary development of the Armored Combat Engineer Battalion, defines the term armored combat engineer, identifies current organizational structures common in today's armored combat engineer organizations, describes future warfare, and identifies future trends in military organizational design.

The principle findings from the analysis and evaluation indicates that an Armored Engineer Battalion organized around core battlefield missions will be more effective on the twenty-first century battlefield than the Current Armored Engineer Battalion. The findings fully support the research hypothesis.

CONTENTS

ILLUSTRATIONS

LIST OF TABLES

CHAPTER 1 - INTRODUCTION

Is modularity the next step in the evolution of the Armored Engineer Battalion? An Armored Engineer Battalion consisting of modular, capabilities-based units designed around core battlefield missions may be the solution to meet the operational demands on the Armored Engineer Battalion of the twenty-first century. An Armored Engineer Battalion organized around core battlefield missions, hereafter referred to as the Force XXI Armored Engineer Battalion, was evaluated to determine if it would improve the responsiveness and effectiveness of combat engineer support to the armored or mechanized brigade in full dimensional operations.

Background

A military technology revolution is currently underway.[1] Information age technologies are changing the way the Army fights. Units will soon have to operate over a larger battlespace and at an increased tempo.[2] Force XXI Operations - full-dimensional operations of the early 21st century - will require different organizational structures and different tactics, techniques and procedures as a result

of the temporal and spatial changes expected in 21st century warfare. As the combined arms team moves into the 21st century, the combat engineer community must also adjust its organization and doctrine to effectively support Force XXI operations.[3]

Scope and Purpose

The purpose of this paper is to offer an alternative design concept for the future divisional Armored Engineer Battalion. The effectiveness of the Force XXI Armored Engineer Battalion was evaluated against, and compared to, the Current Armored Engineer Battalion organization. The focus of this monograph is on organizational change designed to improve the effectiveness of the future Armored Engineer Battalion. The impact that changes in doctrine, training, leader development, and material could have on organizational effectiveness is not discussed in detail.

Importance

Recent Advanced Warfighting Experiments (AWEs) have highlighted numerous limitations of the current Armored Engineer Battalion organizational structure.[4] A possible organizational solution to provide effective and responsive combat engineer support to the armored and mechanized brigade on the future battlefield is evaluated in this monograph. The results of this study could possibly

influence the U.S. Army Training and Doctrine Command's (TRADOC's) design of the future Armored Engineer Battalion.

Principal Research Question

The primary question that this monograph will address is: Will an Armored Engineer Battalion organized around core battlefield missions be more effective in supporting the armored or mechanized brigade in full-dimensional operations than the Current Armored Engineer Battalion? The research hypothesis is that an Armored Engineer Battalion organized around core battlefield missions would be more effective in supporting the armored or mechanized brigade in full-dimensional operations than the Current Armored Engineer Battalion.

Assumptions

There are five underlying assumptions that were key to this research. First, the simple spatial and temporal analysis techniques used to evaluate the Current Armored Engineer Battalion are able to adequately distinguish between unit capabilities and unit design characteristics. Second, there are four core combat missions for the Armored Engineer Battalion: a) breaching obstacles (natural or man-made) to enable the maneuver of friendly forces; b) constructing obstacles that impede or alter the movement of enemy forces in order to enhance the supported commander's efforts in accomplishing his mission; c) constructing battle

positions to protect and conceal maneuver forces; and d) terrain reconnaissance to support the rapid movement of friendly forces.[5] Third, meaningful results can be obtained on the effectiveness of an organization by primarily looking at spatial and temporal variables. Fourth, organizational changes alone (without doctrine, training, leader development, and material changes) will be significant enough to improve the effectiveness of the Armored Engineer Battalion in support of Force XXI operations. And, fifth, Force XXI design principles for the division can be applied at lower echelons.[6]

Research Design

The Force XXI Armored Engineer Battalion (the Force XXI Armored Engineer Company designed around core battlefield missions is at figure 1) was evaluated against the Current Armored Engineer Battalion (the Current Armored Engineer Company organized by function is at figure 2)[7] to determine which type of organization is most effective in supporting an armored or mechanized brigade. The Current and Force XXI Armored Engineer Battalions remained identical in the number and type of personnel, equipment and engineer companies during the evaluation. The Force XXI Armored Engineer Battalion organizational design incorporated the Force XXI Design guidelines identified in current literature on the subject.[8]

FIGURE 1

FORCE XXI ARMORED ENGINEER COMPANY

ARMORED EN BN, EN BDE, HVY DIV

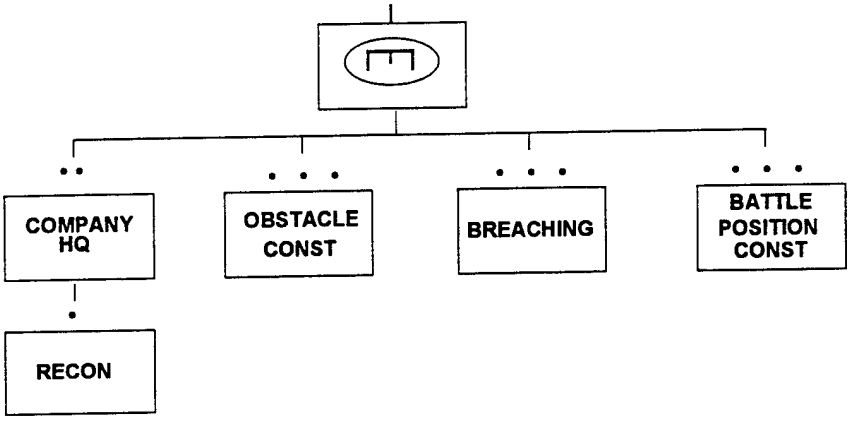
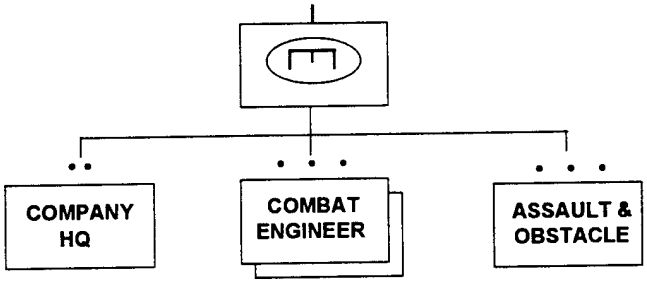


FIGURE 2

CURRENT ARMORED ENGINEER COMPANY

ARMORED EN BN, EN BDE, HVY DIV

TOE 05335L000



Accepted spatial and temporal evaluation methods and techniques were used to determine the effectiveness of each organization.[9] The research design methodology used in this monograph was largely based on the methodology used by TRADOC for the U.S. Army's *Force XXI Division Design Analysis*.[10] The Force XXI Armored Engineer Battalion was evaluated against the current Armored Engineer Battalion in both defensive and offensive scenarios. The scenarios used in this monograph were based on TRADOC's scenario used during the Army's *Force XXI Division Design Analysis* and the scenarios used during recent AWEs (Desert Hammer VI, Mobile Strike Force 95, Focused Dispatch, and Mobile Strike Force 96).[11]

The research methodology consisted of four broad phases. First, a thorough review of current literature was conducted to: 1) identify appropriate design requirements for the Force XXI Armored Engineer Battalion; and 2) identify appropriate spatial and temporal evaluation techniques that are appropriate for this level of study. Second, the Force XXI Armored Engineer Battalion was designed based on applicable Force XXI design principles. Third, offensive and defensive scenarios were developed for use in evaluating the effectiveness of the Current and Force XXI Armored Engineer Battalions in Force XXI operations. And fourth, the effectiveness of the Current and Force XXI Armored Engineer Battalions was determined using appropriate spatial and temporal analysis techniques. The results were

then used to determine the relative effectiveness of each organizational design in supporting Force XXI operations.

Results

As expected, the results from this study supported the hypothesis. The results indicated that the Force XXI Armored Engineer Battalion organization enhances the responsiveness and effectiveness of the Armored Combat Engineer on the future battlefield. The results from this study were similar to the findings from previous experimentation by the U.S. Army with modular, capabilities-based engineer units. The results also validated the organizational concept used in Russian Army engineer organizations.

CHAPTER 2 - BODY

The evolutionary development of the Armored Combat Engineer Battalion is discussed in this chapter. Literary and scholarly works were used to: define the term armored combat engineer; identify current organizational structures common in today's armored combat engineer organizations; describe future warfare; and identify future trends in military organizational design.

Armored Combat Engineer

A military engineer is a person in the military service who is trained in, skilled at, or professionally engaged in the application of scientific principles to achieve practical military (or national) ends.[12] The U.S. Military Academy and the U.S. Army Corps of Engineers were founded to provide and maintain military engineers for national service to the emerging United States of America.[13] There are several literary works that clearly describe this type of military engineer.[14]

A combat engineer is a military engineer who is primarily focused on decreasing or eliminating the friction of the terrain and environment on friendly maneuver forces

and logistical operations. Simultaneously he also increases the negative effects of the terrain and environment the enemy.[15] U.S. Army Field Manual 5-100, Engineer Operations, describes combat engineer functions as mobility, countermobility, survivability, general engineering, and topographic engineering.[16] John Keegan, in his book *Soldiers - A History of Men in Battle*, states that combat engineers "build bridges and roads under enemy bombardment and lift mines under direct enemy fire. They demolish obstacles in advance of their own assaulting infantry, construct defensive positions in the face of enemy attack, [and] remain with the rearguard to impede the enemy's pursuit."[17]

The armored combat engineer, which is the primary focus of this monograph, is more narrowly defined as a soldier that provides routine combat engineer support to armored or mechanized infantry brigades, battalions, or task forces. A 1950 report by the U.S. Armor School on the operation of armored combat engineers in the European Theater of Operations in World War II describes the mission of the armored combat engineer as being "twofold: To facilitate the advance of their own troops, and to impede the advance of enemy troops."[18] The definition of armored combat engineer used throughout this monograph is largely based on the Armor School's 1950 description. The core battlefield missions of the armored combat engineer are: 1) breaching simple and complex obstacles (natural or man-made) to

facilitate the advance of armored or mechanized forces; 2) constructing obstacles to movement that impedes or alters the advance of enemy forces and enhances the maneuver commander's success in accomplishing his mission (usually defeating or destroying the enemy); 3) constructing battle positions that enhance the force protection (survivability) and concealment of maneuver forces; and 4) terrain reconnaissance to support the rapid movement of friendly forces. The armored combat engineer is not organically equipped to, and does not routinely perform, most general engineering missions.[19] The armored combat engineer is a specialized type of military engineer with a narrowly defined mission.

Current Organizational Structures

There are two basic organizational structures for combat engineer units in today's modern armies. The first is a function-based organizational structure where units are designed around core organizational missions.[20] The second is a product-based organizational structure where soldiers and equipment are organizationally grouped by individual function or resource.[21]

Function-based Organizational Structure

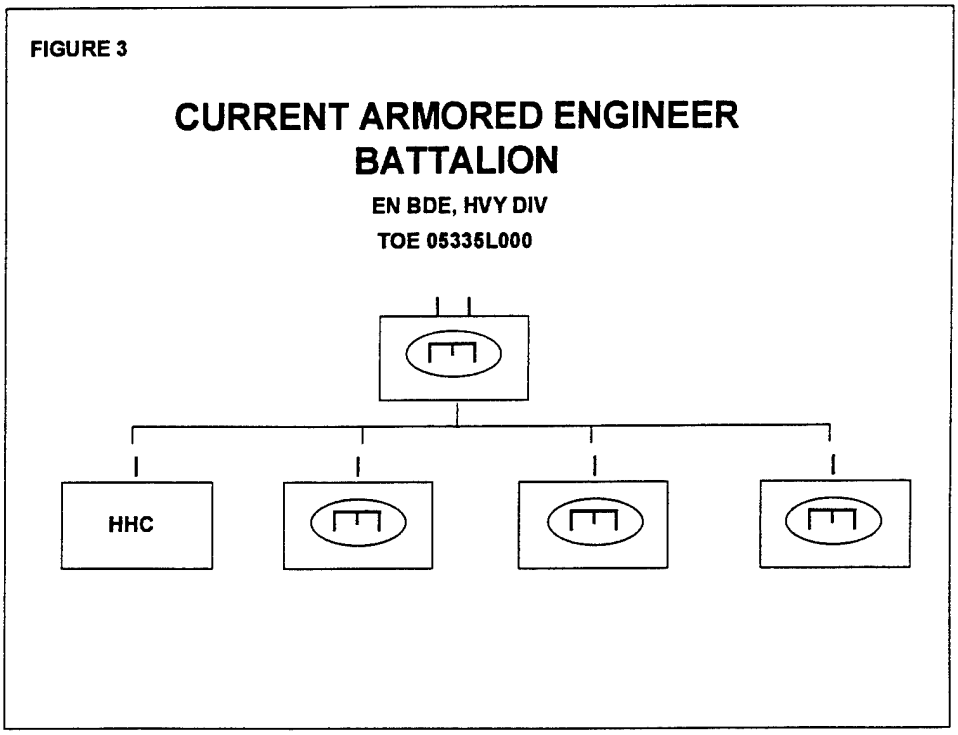
The function-based organizational structure is used by many commercial construction and civil engineering firms and is characteristic of many U.S. Army combat engineer

battalions. The distinct characteristic of a function-based organizational structure is that soldiers and equipment are organizationally grouped by resources. Each organization provides resources to temporary task forces and organizations that are formed to accomplish a particular mission. The main strengths of a function-based organizational structure is that it enables in-depth individual skill development and organizational efficiency.[22]

The primary weakness of a function-based organizational structure is that it hinders coordination, cooperation and team building with other organizations. The function-based organizational structure requires command and control capabilities at multiple echelons to build and lead the team of resources formed to accomplish collective missions. Also, the function-based organizational structure tends to promote the allegiance of its members towards functional goals rather than corporate goals and objectives.[23]

The current U.S. Army Armored Engineer Battalion organizational structure is depicted in figure 3. Each Armored Engineer Company is composed of a headquarters section, two combat engineer platoons with three combat engineer squads each, and an assault and obstacle platoon consisting of two assault sections and an obstacle section. In the U.S. Army Armored Engineer Company, soldiers and

FIGURE 3



equipment are organizationally grouped by resources. Each company forms temporary task forces and organizations to accomplish a particular core battlefield mission. The organizational design of the Current Armored Engineer Company enables in-depth individual skill development and efficiency among the soldiers and different vehicle operators.[24]

Product-based Organizational Structure

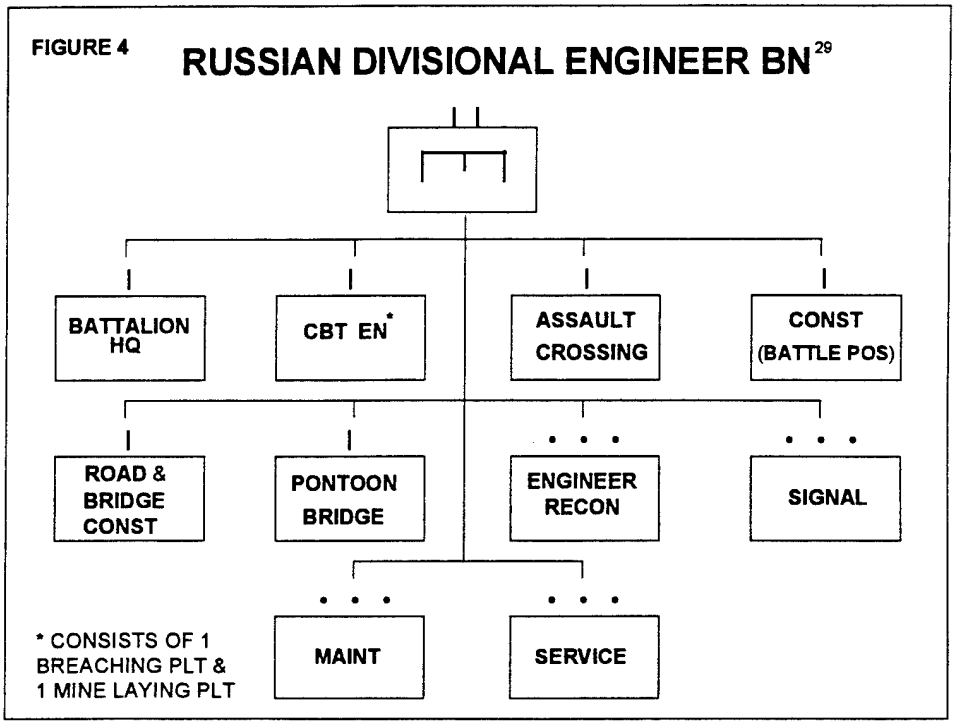
The product-based structure is the organizational structure used by most army organizations. The product-based organizational structure is most effective when goals are external effectiveness and adaptation is an organizational goal. The strengths of a product-based

organizational structure include an ability to rapidly adapt to a changing environment, a decentralization of decision making to platoon and section level, and an ability to develop teamwork and improve coordination across functional lines. The most significant weakness of a product-based organizational structure is that it restricts the development of in-depth individual competence and technical specialization.[25]

The Russian combat engineer organization utilizes a product-based organizational structure and serves as an excellent example to illustrate this organizational type. The Russians have been using product-based organizational structures since the 1943 Battle of Kursk.[26] The Russian Army engineer companies and platoons are made up of modular, capabilities-based units designed around core battlefield missions. The modules are designed to provide a specific engineer capability to a supported unit. Russian military literature strongly supports organizing engineer units around core battlefield missions,[27] and Russian combat engineer strength has been attributed to the "flexibility" and mission "specialization" that results from a product-based organizational structure.[28]

The Russian divisional engineer battalion of the motorized rifle and tank divisions contain several company and platoon-sized organizations that are designed around combat engineer missions (see figure 4). The Russian divisional engineer battalion includes a breaching

FIGURE 4



platoon and a minelaying platoon in the combat engineer company, a road and bridge construction company, a battle position construction company, an engineer reconnaissance platoon, and amphibious, ferry, and bridge units. Unit sub-elements (platoons, sections, and squads) can be detached from the parent unit and assigned to a supported unit for an indefinite period of time.[30] The modular designed platoons, sections, and squads permit the use of specific modules and elements of capability that meet the minimum needs of a commander in a particular mission. The organization is also designed to enable rapid tailorability to support high tempo operations.[31]

Future Military Operations

No one knows for sure what military operations will be like on the twenty-first century battlefield for armored and mechanized brigades, but, if current projections hold true, at least two things seem certain. Both battlespace and tempo will increase. The expansion of battlespace for future combat units is described in the following paragraph from *TRADOC Pamphlet 525-5, Force XXI Operations:*

> Looking at conventional and high-intensity warfare, recent military-technical developments point toward an increase in the depth, breadth, and height of the battlefield. This extension of the battlespace with fewer soldiers in it is an evolutionary trend in the conduct of war. The continuing ability to target the enemy, combined with rapid information processing and distribution, smart systems, and smart munitions, will accelerate this phenomenon. As armies seek to survive, formations will be more dispersed, contributing to the empty battlefield. Commanders will seek to avoid linear actions, close in combat, stable fronts, and long operational pauses. Recent U.S. operations show that deep battle has advanced beyond the concept of attacking the enemy's follow-on forces in a sequenced approach to shape the close battle to one of simultaneous attack to stun, then rapidly defeat the enemy. Commanders may place greater emphasis on operational-and/or tactical level raids-combined with deep strike means-to break up an enemy's formations from within. The relationship between fire and maneuver may undergo a transformation as armies with high technology place increasing emphasis on simultaneous strikes throughout the battle space, maneuver forces may be

physically massed for shorter periods of time.[32]

Tempo, likewise, will increase. "Tempo is more than speed; it is adjustment in rate of operations relative to battle circumstance and assessment relative to enemy capability to sense and react."[33] Emerging information processing technologies, improved situational awareness, increased speed of twenty-first century combat vehicles, and the requirement to conduct multiple missions simultaneously and/or in rapid succession are driving the changes in the tempo of twenty-first century warfare. These changes in tempo are greatly increasing the demands on future military organizations.[34] As the armored and mechanized forces increase their ability to both control and increase speed of operations, the rest of the combined arms team must also do likewise.

Future Organizational Trends

Much has been written about twenty first century warfare but only three key military publications address the organizational issues that face the Army of the twenty-first century. *TRADOC Pamphlet 525-5, Force XXI Operations* addresses twenty-first century organizational designs in the context of an operational concept for the strategic Army of the early 21st century. *TRADOC Pamphlet 525-XX, Force XXI Divisional Operations Concept* identifies in broad terms the organizational characteristics of the future division that

will be needed to support Force XXI operations. *TRADOC Pamphlet 525-68, Concept for Modularity* addresses the organizational characteristics of the Army that will be needed to support the rapid force tailoring for the force projection Army in the 21st century.

TRADOC Pamphlet 525-5, Force XXI Operations identifies four organizational requirements for the Army of the twenty-first century. First, the organizational design must allow units to be rapidly tailored to support Force XXI operations. Second, units must be organized "around information processing and dissemination."[35] Third, leader-to-led ratios must be flexible enough to be tailored for specific missions.[36] And, fourth, the Force XXI Army will be organized around the division as the major tactical formation.[37] *TRADOC Pamphlet 525-XX, Force XXI Division Operations* identifies an additional organizational requirement: "organizations must be modular or capable of being task organized for the mission."[38]

TRADOC Pamphlet 525-68, Concept for Modularity identifies five characteristics of the twenty-first century Army:

> (1) Modular designed elements will consist of modules and elements of specific capability.
>
> (2) Modular designed elements will permit TOE sub-elements to be detached from a parent unit and assigned to a contingency force for an indefinite period of time.
>
> (3) Modular designed elements may be achieved by splitting an organization

into separate elements. For example, a "parent" module or element may remain in a secure location (permanently or until it, too, displaces forward) while a force projection module or element deploys independently of the parent.

(4) Modular designed elements may be created as teams to provide augmentation to units requiring special capabilities for specific missions.

(5) Modular designed elements will permit projection of specific modules and elements of capability that meet the minimum needs of a commander in contingency operations, with additional modules and elements provided as events require.[39]

Army Chief of Staff General Gordon R. Sullivan distilled the future organizational requirements discussed in the three TRADOC pamphlets into nine Force XXI design principles. General Sullivan described the Force XXI design principles as capabilities to:

- Organize to optimize information-based operations.
- Dominate battlespace: speed, space and time.
- Control battlefield tempo with overwhelming lethality and superior survivability.
- Mount, execute and recover from operations simultaneously.
- Execute quick, decisive victory with minimum casualties.
- Remain rapidly deployable and operationally agile.
- Enhance tailorability through modularity across the force.

- Divert tasks that inhibit the division's primary mission: to fight and win battles and engagements.

- Maintain effectiveness in war and operations other than war as part of joint and multinational teams in all operational environments.[40]

The Force XXI organizational designs for combat, combat support, and combat service support units at echelons below division should be designed to support, and be fully integrated into the future division. Most of the future division design characteristics are applicable at the battalion and company level. The literature indicates that the future Armored Combat Engineer Battalion will need to be made up of modular, capabilities-based units designed around core battlefield missions. The modules should be designed to provide a specific engineer capability. TOE sub-elements should be able to be detached from the parent unit and assigned to a supported unit for an indefinite period of time. Modular platoons, sections, and squads should be designed around the minimum engineer capability needed by a supported commander. The future Armored Engineer Battalion organization should also be designed for rapid tailorability to support the high tempo of operations in the twenty-first century.

Past Experimentation

United States Army Engineer units have experimented with modular, capabilities-based organizations in the past in an effort to increase effectiveness when battlespace and tempo were increasing. For example, between 1984 and 1985, the commander of the 10th Armored Engineer Battalion of the 3rd Infantry Division (Mech) organized platoons around core battlefield missions with great success. He formed mine (counter-mobility) platoons, mobility platoons, support (survivability) platoons, and demolition platoons. The modular design concept was validated during several exercises and enabled the 10th Armored Engineer Battalion to provide responsive and effective support to the 3rd Infantry Division (Mech) as it implemented AirLand Battle doctrine and fielded the new M-1 Main Battle Tank and the M2 Bradley Fighting Vehicle.[41]

The U.S. Army Engineer students who were enrolled in the Battle Command Elective during the 1995/96 U.S. Army Command and General Staff Officer Course, experimented with the Force XXI Armored Engineer Battalion organization during the Mobile Strike Force 96 Advanced Warfighting Experiment conducted at Fort Leavenworth, Kansas in the Spring of 1996.[42] The Force XXI Armored Engineer Battalion organization was placed in the organizational database of the *Confederation of Models* that was used to simulate military operations in the twenty-first century. Due to the limited resolution of the *Confederation of Models*, detailed

evaluation and analysis could not be conducted, but two key insights emerged.[43]

First, the students who were acting as maneuver commanders during the exercise easily understood what engineer capabilities they had available in the Force XXI Armored Engineer Battalion. For example, maneuver task force commanders understood that a breach section had the capability to put in a breach lane through a complex obstacle, an obstacle section had the capability to put in a VOLCANO minefield, and a battle position construction platoon had the capability to construct a company battle position in a couple of hours. When the current organization design was used, the student commanders were often unclear as to what engineer capability they had available to them. Contrary to what many students assumed, a combat engineer platoon (unless augmented with vehicles from the assault and obstacle platoon) only has manual breaching and minelaying capability. Likewise, the assault and obstacle platoon did not have the capability to effectively breach and emplace obstacles without augmentation from engineer squads.[44]

Second, the Force XXI Armored Engineer Battalions appeared to decrease the organizational friction experienced with the Current Armored Engineer Battalion organization. Mr. Richard Schuler, the engineer analyst with the Battle Command Training Program's Operations Group Alpha, observed that the Force XXI Armored Engineer Battalion nearly

eliminated the internal task organizing within engineer units that occurred during Battle Command Training Program exercises using the current organization. Schuler also indicated that the Force XXI Armored Engineer Battalion organization more closely replicated how engineers actually operated on the battlefield.[45]

Conclusion

The armored combat engineer provides routine combat engineer support to armored or mechanized infantry brigades, battalions, or task forces. The Armored Combat Engineer Battalion organization has evolved along two distinctly different paths since World War II. The first is a function-based organizational structure (the U.S. Armored Engineer Battalion model) where soldiers and equipment are organizationally grouped by individual function or resource. The second is a product-based organizational structure (the Russian Army model) where units are designed around core organizational missions.

The future battlefield will be characterized by increased battlespace and tempo and the Army will require new organizational designs to adapt to the changing nature and environment of future warfare. Current literature indicates that the future Armored Combat Engineer Battalion will need to have a product-based organizational structure composed of modular, capabilities-based units designed around core battlefield missions. Past experimentation also

indicates that the organizational effectiveness of the Armored Engineer Battalion may improve on the future battlefield when a product-based organizational structure is used.

CHAPTER 3 - ANALYSIS AND EVALUATION

The Current and Force XXI Armored Engineer Battalion organizations are described, analyzed, and evaluated in this chapter. The two Armored Engineer Battalion organizations are evaluated on their ability to support training on core battlefield missions. Also, the effectiveness of the two engineer organizations will be analyzed in terms of organizational friction, tempo, and battlespace in an operational scenario. Additionally, the principle findings and conclusions from the analysis and evaluation are briefly described at the end of this chapter.

The Current Armored Engineer Battalion

The current Armored Engineer Company has evolved from the thirteen man engineer squad organizations used in World War II.[46] At that time, the combat engineer companies closely resembled the infantry company organizational model. The primary differences between the two organizations were an increased number of crew served weapons in the infantry company and the addition of some specialized engineer equipment in the engineer company.[47]

The U.S. Army's Armored Engineer organization did undergo a significant organizational change during the U.S. Army's Engineer Restructure Initiative (ERI) that occurred in the mid to late 1980s.[48] The ERI re-organization transferred combat engineers from echelon above division to within the U.S. Army armored and mechanized division structure. This enabled each ground maneuver brigade to be supported by an Armored Engineer Battalion.[49] One of the major driving forces behind the Engineer Restructure Initiative was the requirement for a total Army engineer organization that could effectively support the demands brought on by the AirLand Battle Doctrine.[50] The Current Armored Engineer Battalion (the armored engineer company is depicted in figure 5) retains much of the functional design characteristics of its predecessors. It did undergo a significant reduction of personnel due to: increased mechanization, a focus on offensive operations, and increased logistical integration into the rest of the combined arms team.[51]

The Force XXI Armored Engineer Battalion

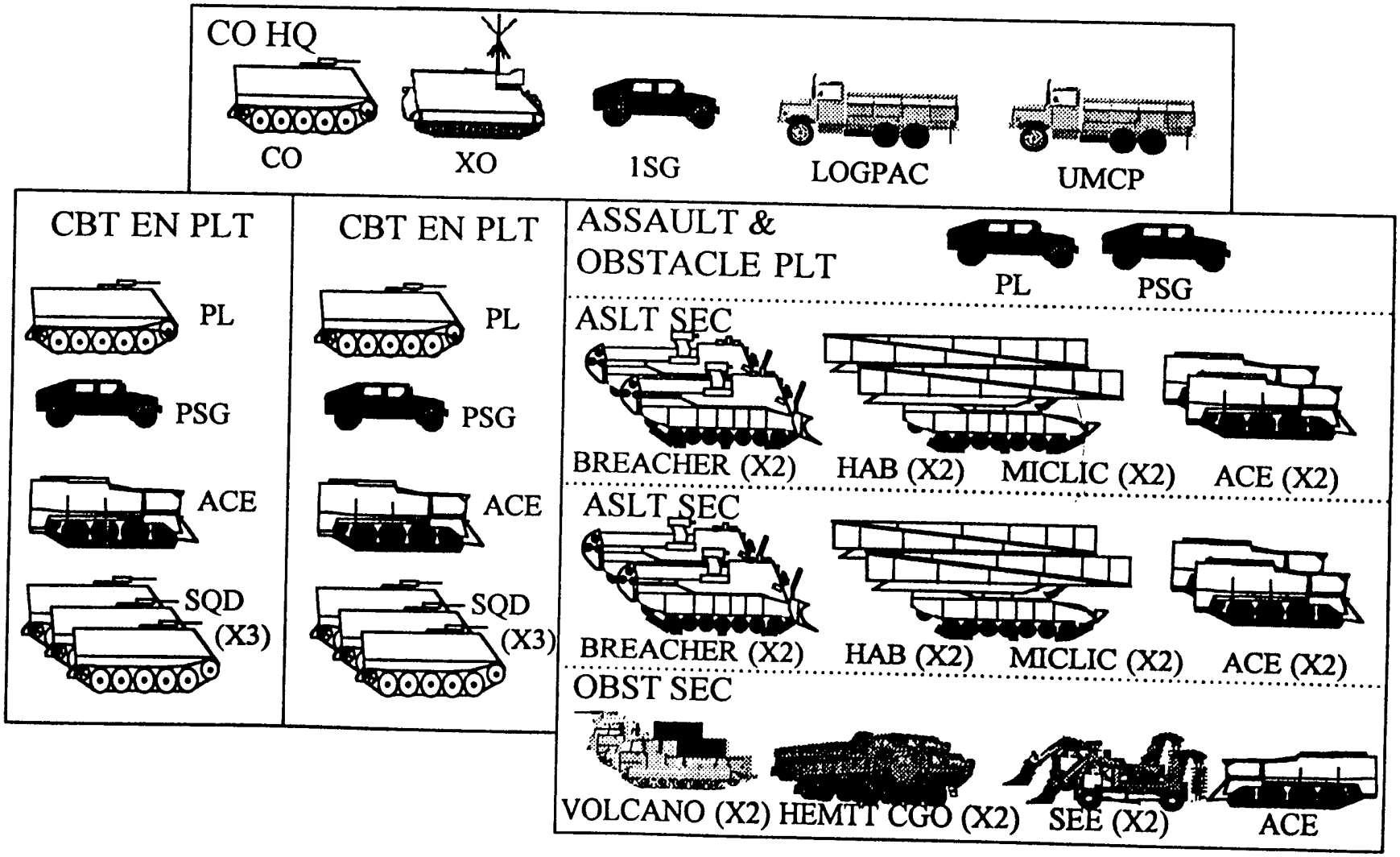
The Force XXI Armored Engineer Battalion design incorporates the organizational trends and guidance discussed in Chapter 2 and identified in the following sources:

FIGURE 5

CURRENT ENGINEER COMPANY

EN BN, EN BDE, HVY DIV

TOE 05335L000



- *TRADOC Pamphlet 525-5, Force XXI Operations*

- *TRADOC Pamphlet 525-XX, Force XXI Divisional Operations Concept*

- *TRADOC Pamphlet 525-68, Concept for Modularity*

- *Force XXI Design Principles*

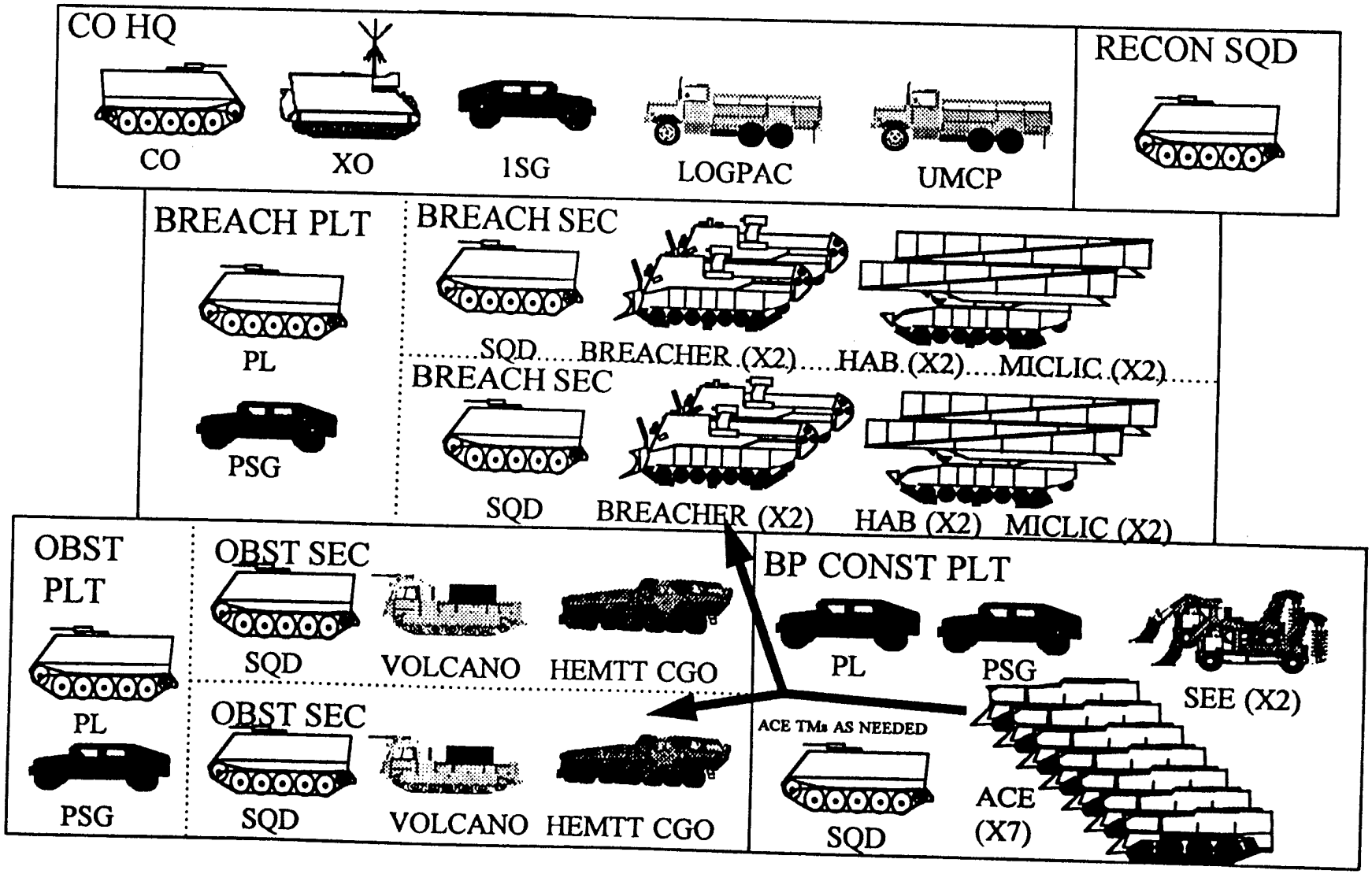
The Force XXI Armored Engineer Battalion consists of three armored engineer companies made up of modular, capabilities-based units designed around core battlefield missions (see figure 6). The modules were designed to provide a specific engineer capability. TOE sub-elements (platoons, sections, and squads) can be detached from the parent unit and assigned to a supported unit for an indefinite period of time. The modular designed platoons, sections, and squads permit the use of specific modules and elements of capability that meet the minimum needs of a commander in a particular mission. The organization is also designed to enable rapid tailorability to support the high tempo of Force XXI operations.[52]

The Force XXI Engineer Battalion is identical to the Current Armored Engineer Battalion with respect to the numbers and types of personnel and equipment. The Force XXI Armored Engineer Battalion also retains the same organizational structure as the Current Armored Engineer Battalion (each have a headquarters and headquarters company and three combat engineer companies). The major difference is that the platoons and sections of the Force XXI Armored

FIGURE 6

FORCE XXI ENGINEER COMPANY

EN BN, EN BDE, HVY DIV



Engineer Battalion are internally organized around the core combat engineer missions of:

- Breaching obstacles (natural or man-made) to enable the maneuver of friendly forces.

- Constructing obstacles that impede or alter the movement of enemy forces in order to enhance the supported commander's efforts in accomplishing his mission.

- Constructing battle positions to protect and conceal maneuver forces.

- Terrain reconnaissance to support the rapid movement of friendly forces.[53]

Organizational Analysis

The organizational analysis performed in this monograph was based on the analysis guidelines outlined in *Organization Theory and Design* by Richard L. Daft.[54] The analysis was based on the general organizational characteristics of the Current and the Force XXI Armored Engineer Battalions as defined by Daft. The Current Armored Engineer Battalion organization is characterized by a function organizational structure. Soldiers are generally organized by military occupational specialty or skill, and equipment is organizationally grouped by type. Equipment and personnel are provided as resources to temporary task forces and organizations that are formed to accomplish core battlefield missions. Platoons and sections are incapable of performing many of their core battlefield missions to the desired standard without augmentation from another platoon

or section. The organizational analysis results of the Current Armored Engineer Battalion are summarized in table 1.[55]

TABLE 1

CURRENT ARMORED ENGINEER BATTALION

• STRENGTHS	• WEAKNESSES
– "Allows economies of scale" to support individual training.	– "Has slow response time to environmental changes."
– "Enables in-depth [individual] skill development."	– "Leads to poor horizontal coordination" and integration.
– "Is best when only one or a few" missions need to be performed.	– "Results in less innovation."

Daft, pp. 226-7

The Force XXI Armored Engineer Battalion is characterized by a product organizational structure. The product organizational structure is used by most army organizations. The modular "self-contained" units are designed to have the capability to accomplish particular core battlefield missions. The organizational analysis results of the Force XXI Armored Engineer Battalion are summarized in table 2.[56]

The organizational analysis indicates that the Current Armored Engineer Battalion organization performs best in a

TABLE 2

FORCE XXI ARMORED ENGINEER BATTALION

- STRENGTHS
  - "Is suited to fast change in an unstable environment"
  - "involves high coordination across functions" and horizontal integration
  - "decentralizes decision making"
- WEAKNESSES
  - "Eliminates economies of scale" to support individual training.
  - "Eliminates in-depth competence and technical specialization."
  - "Leads to poor coordination" between modular units.

Daft, pp. 230-3

stable environment where efficiency and quality is more important than effectiveness, and horizontal integration across engineer functions is not a high priority. The vertical chain of command can also get "overloaded" in a rapidly changing environment and not be able to "respond fast enough."[57]

The Force XXI Armored Engineer Battalion organization performs best in an uncertain and rapidly changing environment where effectiveness is more important than quality and efficiency, and effective horizontal integration across engineer functions is required. The Force XXI Armored Engineer Battalion organization also fosters decentralized decision making by subordinate leaders.[58]

Training Analysis

The Current and Force XXI Armored Engineer Battalions were analyzed to determine which organization best supports the U.S. Army's concept of battle focused training. "Battle focus[ed] training is a concept used to derive peacetime training requirements from wartime missions."[59] *U.S. Army Field Manual 25-100, Training the Force,* and *U.S. Army Field Manual 25-101, Battle Focused Training* were used as the basis for analyzing the two Armored Engineer Battalion organizations. The following principles of training, identified in Field Manual 25-100 were used as the framework for this analysis:

√ 1) Train as a Combined Arms and Services Team.

√ 2) Train as You Fight

3) Use Appropriate Doctrine

√ 4) Use Performance-Oriented Training

5) Train to Challenge

√ 6) Train to Sustain Proficiency

√ 7) Train Using Multiechelon Techniques

√ 8) Train to Maintain

√ 9) Make Commanders the Primary Trainers[60]

The training principles identified above with a check mark ("√") highlighted a distinct difference between the training abilities/capabilities of the two Armored Engineer

Battalion organizational designs. The key element of *Train as a Combined Arms Team* is that "each unit must be prepared to execute combined arms and services operations without additional training or lengthy adjustment periods."[61] The platoons and sections in the Current Armored Engineer Battalion are not organized around core battlefield missions, nor are they organized like they would fight with an armored or mechanized combined arms team.[62] Vehicles and personnel must be brought together from different platoons and sections to produce a product. [For example: a VOLCANO minefield requires a VOLCANO minelayer from the obstacle section plus engineer squad members from another platoon to layout the minefield and mark it;[63] a breach requires a breacher plus an engineer squad from another platoon to mark the breach lane and guide vehicles through the lane;[64] and, Armored Combat Earthmovers (ACEs) routinely operate in pairs but each combat engineer platoon and the obstacle section only has one ACE.][65] This requires numerous internal organizational adjustment periods and additional collective training (usually in the form of engineer rehearsals) before the engineer platoons and sections can adequately perform their required missions with their supported unit. The Force XXI Armored Engineer Battalion, on the other hand, is already designed around its core battlefield mission and requires little or no internal adjustment periods prior to integration into combined arms training and/or operations.[66]

Key to a unit's ability to *Train as You Fight* and conduct *Performance Oriented Training* is that a unit is organized as it fights. It is nearly impossible for a combat engineer platoon or section leader in the Current Armored Combat Engineer battalion to perform his core battlefield missions in training when he doesn't have the assets in his platoon or section to perform many of his missions. He is forced to rely on augmentation from another platoon or section to perform collective training tasks. The Force XXI Armored Engineer Battalion is organized and equipped so that the platoons and sections can train as they would fight on the battlefield.[67]

The principles of *Train to Sustain Proficiency* and *Train using Multiechelon Techniques*, as described in *Field Manual FM 25-100, Training the Force,* states that "leaders must structure collective and individual training plans to repeat critical task training at the minimum frequency necessary for sustainment."[68] The platoon, company, and battalion commanders in the Current Armored Engineer Battalion can easily structure individual training plans, but structuring collective training plans are more difficult because of the requirement to transfer resources between platoons and sections to support collective training events. Collective training is much easier to structure in the Force XXI Armored Engineer Battalion because the sections and platoons are organized so they have all the personnel and equipment needed to perform their core battlefield missions.

Collective training in the Force XXI Armored Engineer Battalion can be conducted independent of other engineer unit training plans.[69]

For units to *Train to Maintain*, leaders and supervisors must be familiar with the maintenance requirements for equipment that they will use in performing their core battlefield missions. The Current Armored Engineer Battalion organizational structure in many instances causes one leader or supervisor to be responsible for maintenance in peacetime while making another leader/supervisor responsible for supervising the maintenance of that piece of equipment on the battlefield (this may contribute to the decrease in equipment readiness that is currently being experienced by most engineer units at the combat training centers).[70] The Force XXI Armored Engineer Battalion minimizes the amount of maintenance intensive equipment that is transferred between engineer platoons and sections, and clearly enables engineer units to train to maintain their equipment.[71]

The last training principle, *Make Commanders the Primary Trainers*, is fundamental to battle focused training. "Leaders in the chain of command are responsible for the training and performance of their soldiers and units."[72] In the Current Armored Engineer Battalion it is often the rule, not the exception, that platoon and section leaders are responsible for core collective training tasks that involve personnel and equipment that they do not control, supervise,

and/or train in peacetime.[73] The Force XXI Armored Engineer Battalion is organized in a manner that enables section and platoon leaders to be fully responsible for training and performance of their soldiers and units.[74]

The training analysis performed to determine which organization best supports the U.S. Army's concept of battle focused training indicates that an organization designed around core battlefield missions is more capable of developing, maintaining, and executing a training program that is focused on wartime missions. The combat engineer platoons and sections in the Current Armored Engineer Battalion are forced to develop and execute training programs that include the four core battlefield missions without "owning" the resources needed to support the training. The training analysis also validated the long recognized strength of the Russian Army's product-based engineer organization to focus training in units on one engineer battlefield mission.[75]

Effectiveness Analysis

The Current and Force XXI Armored Engineer Battalions were evaluated on a computer-simulated, futuristic battlefield to determine which organizational design was most effective in providing armored engineer support to ground maneuver units. Both offensive and defensive scenarios were used in the evaluation. Organizational friction, tempo and battlespace[76] were measured and used as

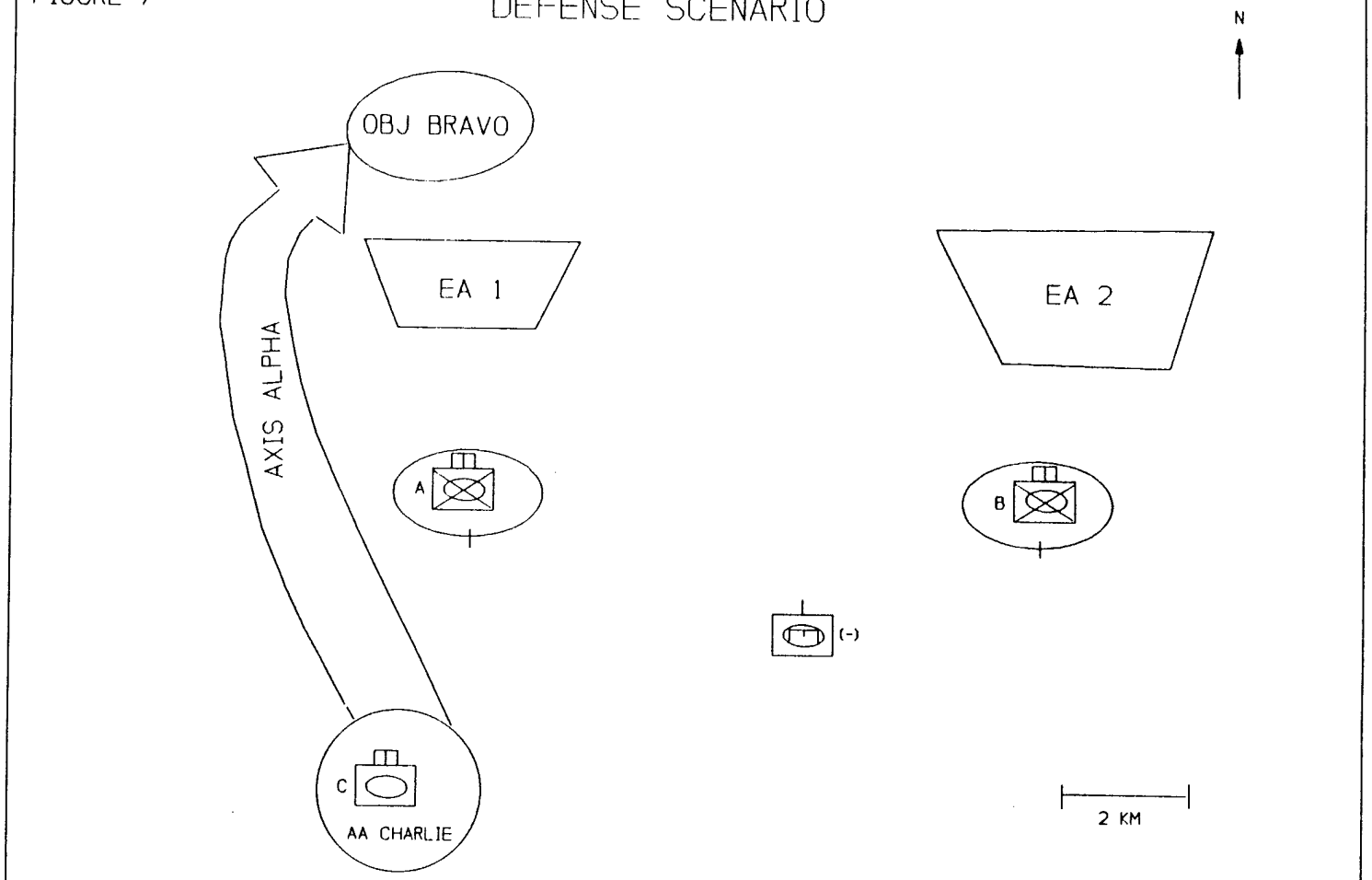
indicators of the effectiveness of the two organizations. The commercial software package *EasyCAD* was used as a geographic information system to capture the data needed for this study.[77] Organizational friction was measured by the number of internal link-up operations that had to take place to arrive at a task organization that could execute engineer missions in the scenarios. Tempo was measured by how long it took to form the engineer task organizations and link them up with their supported units. Battlespace was measured by the square kilometers of battlespace that the engineer platoons and sections were operating in.

The scenarios used in this study are depicted in figures 7 and 8. Both the defensive and offensive scenarios involved a mechanized task force with two mechanized infantry company teams, one armor company team, and one armored engineer company in support. In the defensive scenario, Company Team Alpha, the main effort, is defending in the west in a battle position, and is responsible for developing ENGAGEMENT AREA 1. Company Team Bravo is defending in the east in a battle position, and is responsible for developing ENGAGEMENT AREA 2. Company Team Charlie attacks along AXIS ALPHA to defeat enemy forces in OBJ BRAVO.

The offensive scenario is a continuation of the defensive scenario. Company Team Alpha, the main effort, attacks along AXIS HOTEL to defeat enemy forces in OBJ ECHO.

FIGURE 7

DEFENSE SCENARIO



PRODUCED FROM THE EZCAD GEOGRAPHIC INFORMATION SYSTEM

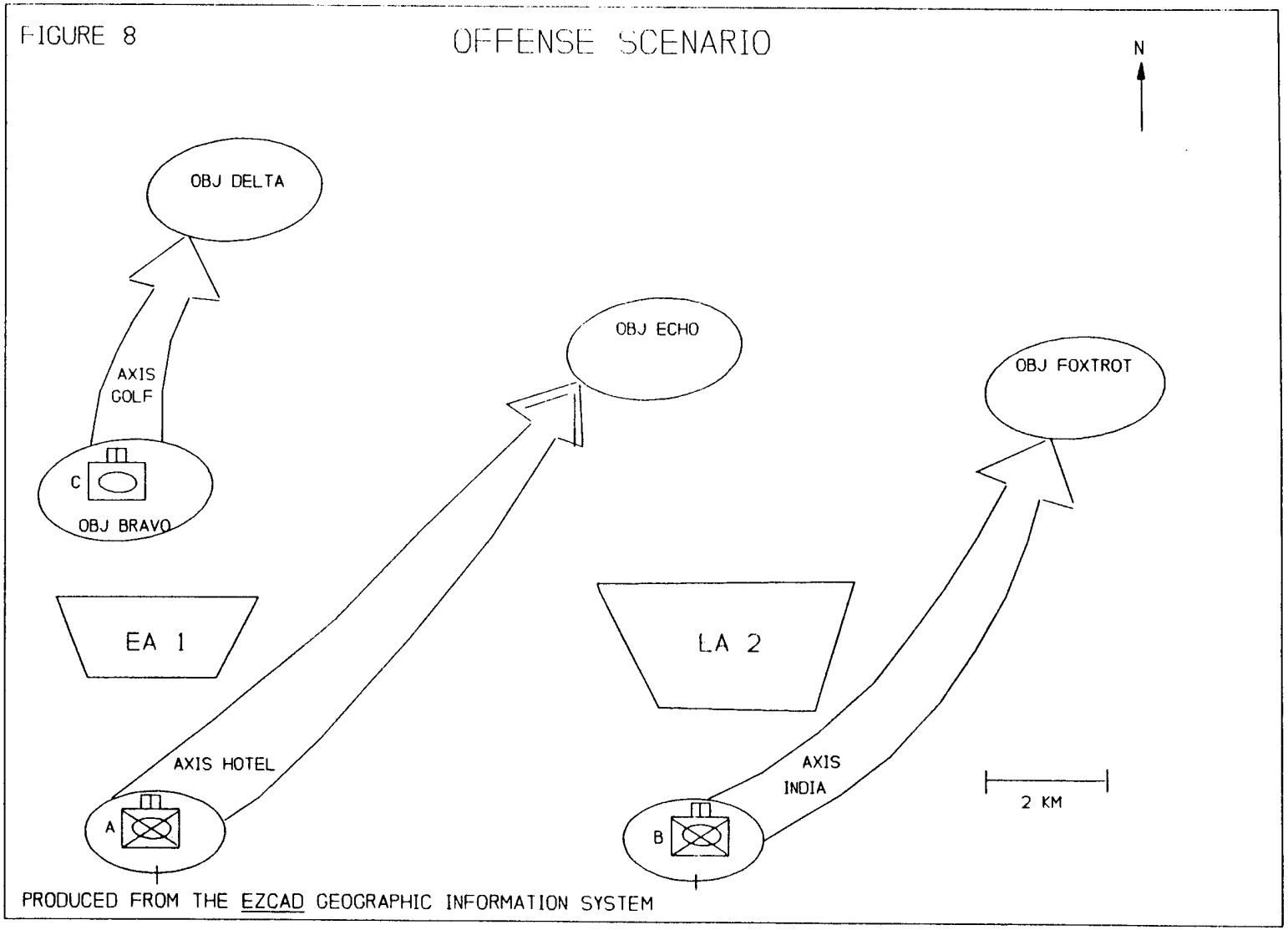


FIGURE 8
OFFENSE SCENARIO
N
OBJ DELTA
OBJ ECHO
OBJ FOXTROT
AXIS
GOLF
C
OBJ BRAVO
EA 1
LA 2
AXIS HOTEL
AXIS
INDIA
A
B
2 KM
PRODUCED FROM THE EZCAD GEOGRAPHIC INFORMATION SYSTEM

Company Team Bravo attacks along AXIS INDIA to defeat enemy forces in OBJ FOXTROT and secure Company Team Alpha's right flank. Company Team Charlie attacks along AXIS GOLF to defeat enemy forces in OBJ DELTA and secure Company Team Alpha's left flank.

Organizational Friction

Organizational friction was measured by the number of internal link-up operations that the engineer company had to perform to arrive at the task organization required to support the mechanized task force in the scenarios (appendices A - P). The internal link-up operations needed to support the defense are in table 3.

TABLE 3

INTERNAL LINK-UP OPERATIONS (DEFENSE)

CURRENT ARMORED ENGINEER COMPANY (APPENDICES A-G)

	UNITS/VEHICLES	FROM	TO
1.	VOLCANO & HEMTT	OBSTACLE SEC	EA 1 (SQUAD - 1 PLT)
2.	SEE TM	OBSTACLE SEC	CO TM A BP (SQUAD - 1 PLT)
3.	ACE TM	ASSAULT SEC 1	CO TM A BP (SQUAD - 1 PLT)
4.	ACE TM	ASSAULT SEC 2	CO TM A BP (SQUAD - 1 PLT)
5.	ACE	OBSTACLE SEC	CO TM B BP (ACE - 2 PLT)
6.	VOLCANO & HEMTT	OBSTACLE SEC	EA 2 (SQUAD - 2 PLT)
7.	SQUAD (2 EA)	2 PLT	AA CHARLIE (A&O PLT/CO TM C)
8.	ASLT SEC (-)	A&O PLT	EN CO HQ

FORCE XXI ARMORED ENGINEER COMPANY (APPENDIX H)

	UNITS/VEHICLES	FROM	TO
1.	OBST SEC 1	OBST PLT	EA 1
2.	ACE TM	BP CONST PLT	CO TM B BP
3.	BREACH SEC 2	BREACH PLT	EN CO HQ

The internal link-up operations needed to support the offense are in table 4.

TABLE 4

INTERNAL LINK-UP OPERATIONS (OFFENSE)*

CURRENT ARMORED ENGINEER COMPANY (APPENDICES I-O)

UNITS/VEHICLES	FROM	TO	THEN TO
1. ASLT SEC 1 (-)	OBJ BRAVO	(SQUAD - 1 PLT)	5. CO TM A BP
2. ASLT SEC 2 (-)	EN CO HQ	(SQUAD - 2 PLT)	6. CO TM B BP
3. ACE TM	CO TM A BP	(SQUAD - 2 PLT)	7. OBJ BRAVO
4. VOLCANO & HEMTT	EA 1	(SQUAD - 2 PLT)	8. OBJ BRAVO

FORCE XXI ARMORED ENGINEER COMPANY (APPENDIX P)

UNITS/VEHICLES	FROM	TO
1. OBST SEC 1	EA 1	OBJ B
2. ACE TM	CO TM A BP	OBJ B
3. BREACH SEC 2	EN CO HQ	CO TM B BP
4. RECON SQUAD & BREACH SEC 1	OBJ B	CO TM A BP

* NOTE: Assumes that the platoon leaders do not try and consolidate their platoons in an assembly area prior to change of mission. If the platoon leaders were to consolidate their platoons prior to change of mission (which is a common and often a natural leadership practice) the results in table 4 would closely resemble the results in table 3.

The results show that the Force XXI Armored Engineer Battalion performed less than forty per cent of the internal link-up operations required by the Current Armored Engineer Battalion to support the mechanized task force in the defense. Similarly, the internal link-up operations performed by Force XXI Armored Engineer Battalion to support the mechanized task force in the offense were 50% of those conducted by the Current Armored Engineer Battalion. The organizational friction analysis indicated that the Force XXI Armored Engineer Battalion will experience less

organizational friction on the future battlefield because it requires fewer internal link-up operations and organizational adjustments.

Tempo

Tempo was measured by how long it took for engineer units to transition from the task organization in the defense to the task organization in the offense. Time was calculated based on a vehicle speed of twenty kilometers per hour for all engineer vehicles over the most direct route. Ten minutes were added for each internal link-up operation that had to occur during the transition. The tempo analysis results are depicted in table 5.

TABLE 5

TEMPO

(TIME TO TRANSITION FROM DEFENSE TO OFFENSE)

• CURRENT ARMORED ENGR CO MOVEMENT*	• FORCE XXI ARMORED ENGR CO MOVEMENT*
– ASLT SEC 1 **31 MIN****	– OBST SEC 1 **21 MIN**
– ASLT SEC 2 25 MIN**	– BREACH SEC 15 MIN
– VOLCANO & HEMTT **31 MIN****	– RECON SQD & BREACH SEC **21 MIN**
– ACE TM 21 MIN	– ACE TM **21 MIN**

*ASSUMES PLATOON LEADERS DO NOT CONSOLIDATE SUB-UNITS IN AN ASSEMBLY AREA PRIOR TO CHANGE OF MISSION. IF PLATOON CONSOLIDATION DOES OCCUR, THE CURRENT ARMORED ENGINEER COMPANY NEEDS EVEN MORE TIME TO TRANSITION FROM THE DEFENSE TO THE OFFENSE THAN THE FORCE XXI ARMORED ENGINEER COMPANY.

** TEN MINUTES WERE ADDED TO THE MOVEMENT TIME BECAUSE THESE SECTIONS AND/OR VEHICLES HAD TO LINK-UP WITH AN ENGINEER SQUAD.

The tempo analysis indicated that the Force XXI Armored Engineer Battalion could transition to a new mission 32% faster than the Current Armored Engineer Battalion. This was possible because the Force XXI Armored Engineer Battalion performed fewer internal link-up operations.

Battlespace

Battlespace was calculated by measuring the maximum number of square kilometers that each engineer platoon and section were operating in during each scenario. The square kilometer area of battlespace for each engineer unit was measured using the *EasyCAD* geographic information system. The results are in tables 6 and 7.

TABLE 6

BATTLESPACE (DEFENSE)

• CURRENT ARMORED ENGINEER CO	• FORCE XXI ARMORED ENGINEER CO
– 1ST PLT 15 KM²	– BREACH PLT 25 KM²
– 2ND PLT 65 KM²	• BREACH SEC 1 4 KM²
– A&O PLT 90 KM²	• BREACH SEC 2 4 KM²
• ASLT SEC 1 18 KM²	– OBSTACLE PLT 33 KM²
• ASLT SEC 2 4 KM²	• OBST SEC 1 6 KM²
• OBST SEC 60 KM²	• OBST SEC 2 6 KM²
	– BP CONST PLT 24 KM²
PLT AVE = 56 KM² SEC AVE = 27 KM²	PLT AVE = 27 KM² SEC AVE = 5 KM²

TABLE 7

BATTLESPACE (OFFENSE)

• CURRENT ARMORED ENGINEER CO	• FORCE XXI ARMORED ENGINEER CO
– 1ST PLT 4 KM^2	– BREACH PLT 30 KM^2
– 2ND PLT 40 KM^2	• BREACH SEC 1 4 KM^2
– A&O PLT 50 KM^2	• BREACH SEC 2 4 KM^2
• ASLT SEC 1 4 KM^2	– OBSTACLE PLT 50 KM^2
• ASLT SEC 2 40 KM^2	• OBST SEC 1 4 KM^2
• OBST SEC 50 KM^2	• OBST SEC 2 4 KM^2
	– BP CONST PLT 50 KM^2
PLT AVE = 31 KM^2 SEC AVE = 31 KM^2	PLT AVE = 43 KM^2 SEC AVE = 4 KM^2

The battlespace analysis indicated that the Force XXI Armored Engineer Battalion's platoons and sections operated over a much smaller battlespace on the twenty-first century battlefield than the platoons and sections in the Current Armored Engineer Battalion. In the defense, the average battlespace of the platoons and sections in the Force XXI Armored Engineer Battalion was significantly less than the platoons and sections in the Current Armored Engineer Battalion. Likewise, in the offense, the sub-elements of the Force XXI Armored Engineer Battalion collectively operated over a smaller battlespace than the platoons and sections in the Current Armored Engineer Company.

Principle Findings

Five principle findings were identified during the analysis and evaluation discussed in this chapter. First, the organizational analysis indicated that the Force XXI Armored Engineer Battalion organization is better suited to the fast changing, dynamic, and unstable environment that can be expected in Force XXI operations. Second, the training analysis indicated that the Force XXI Armored Engineer Battalion is better capable of developing, maintaining, and executing a training program that is focused on wartime missions. Third, the organizational friction analysis indicated that the Force XXI Armored Engineer Battalion experiences less organizational friction on the future battlefield because it requires less internal link-up operations and organizational adjustments. Fourth, the tempo analysis indicated that the Force XXI Armored Engineer Battalion could operate at a faster tempo than the current organization (because the Force XXI Armored Engineer Battalion requires less internal link-up operations and organizational adjustments). And fifth, the battlespace analysis indicated that the Force XXI Armored Engineer Battalion's sections operated over a much smaller battlespace on a twenty-first century battlefield.

Conclusions

The principle findings from the simple and rudimentary analysis and evaluation indicates that the Force XXI Armored

Engineer Battalion will be more effective on the twenty-first century battlefield than the Current Armored Engineer Battalion. The findings fully support, but do not conclusively prove, the research hypothesis: An Armored Engineer Battalion organized around core battlefield missions would be more effective in supporting the armored or mechanized brigade in full-dimensional operations than the Current Armored Engineer Battalion.

CHAPTER 4 - CONCLUSION

Modularity should be considered as the next step in the evolution of the U.S. Armored Engineer Battalion. Modular, capabilities-based engineer units designed around core battlefield missions have the potential to meet the new operational demands resulting from the expanded battlespace and increased tempo on the twenty-first century battlefield. Principle findings from this research fully support the research hypothesis that an Armored Engineer Battalion organized around core battlefield missions would be more effective in supporting the Armored Brigade in full-dimensional operations than the Current Armored Engineer Battalion. The results from this study validate the findings from previous experimentation by the U.S. Army with modular, capabilities-based engineer units, and the organizational concept used by Russian Army engineers.

Principle Findings

The research and analysis resulted in five principle findings. In relationship to the Current Armored Engineer Battalion, a modular, capabilities-based, Force XXI Armored Engineer Battalion:

- Is better suited to the fast changing, dynamic, and unstable environment that can be expected in Force XXI operations.

- Better enables the development, maintenance, and execution of a training program that is focused on wartime missions.

- Experiences less organizational friction on the future battlefield because it requires less internal link-up operations and organizational adjustments.

- Can operate at a faster tempo.

- Enables sub-units to operate over a much smaller battlespace which enhances command and control of, logistics support for, unit morale in, and responsiveness of Armored Engineers.

Research Insights

In addition to the principal findings, four key insights emerged from this research: First, effective Armored Engineer organizations are more organic than mechanistic in nature.[78] Engineer personnel and equipment tended to "naturally form" modular, capabilities-based units during the computer simulation. These capabilities based units generally stayed intact during the transition from one mission to another and were only separated when the function organizational structure of the Current Armored Engineer battalion "pulled them apart." This insight is also supported by recent engineer observations during live simulation exercises at the Combat Maneuver Training Center.[79] The Force XXI Armored Engineer Battalion organization more closely captures the engineer organizations that naturally form on the battlefield.

Second, the building of temporary task forces from multiple sub-units in the Current Armored Engineer Battalion works against the unit cohesion that is required on the modern battlefield. Even though unit cohesion could not be measured with the analytical tools used in this monograph, it became obvious that unit cohesion would become a problem when tempo is increased and sequential and continuous operations are performed. Every few hours engineer squads were being linked up with minelaying or breaching vehicle crews from another platoon. Something similar occurred with the individual ACE operators. Small-unit cohesion should be considered in the design of future engineer organizations. S.L.A. Marshall's observation that when a leader tried to lead men in battle that he had never seen or worked with before, "the results were almost uniformly unsuccessful" is probably applicable to engineer units on the future battlefield.[80]

Third, the Current Armored Engineer Battalion is well organized for an environment that is complex in detail, but is not well suited for the dynamically complex, twenty-first battlefield. During the simulations, the Current Armored Engineer Company had almost twice as many moving parts on the twenty-first century battlefield as the Force XXI Armored Engineer Company. The Force XXI Armored Engineer Company was made up of just six key sub-systems (a reconnaissance squad, two breach sections, two obstacle sections, and a battle position construction platoon). The

Force XXI Armored Engineer Company leaders functioned as managers for a few key systems rather than having to manage numerous pieces and parts. The capabilities-based modules used in the Force XXI Engineer Company were "satisficed" rather than optimized to meet mission requirements of the Force XXI Armored Engineer Company. The research presented in this monograph supports the theory that organizations must be effective rather than efficient if they are to be relevant in the complex, adaptive environment of twenty-first century warfare.[81]

Fourth, there is some resistance to a modular, capabilities based Armored Engineer Battalion from many engineer officers in the field. I received numerous comments on the proposed design concept of a modular, capabilities based Armored Engineer Battalion from my peers. Some of the most common comments and my responses to them are at Annex S.

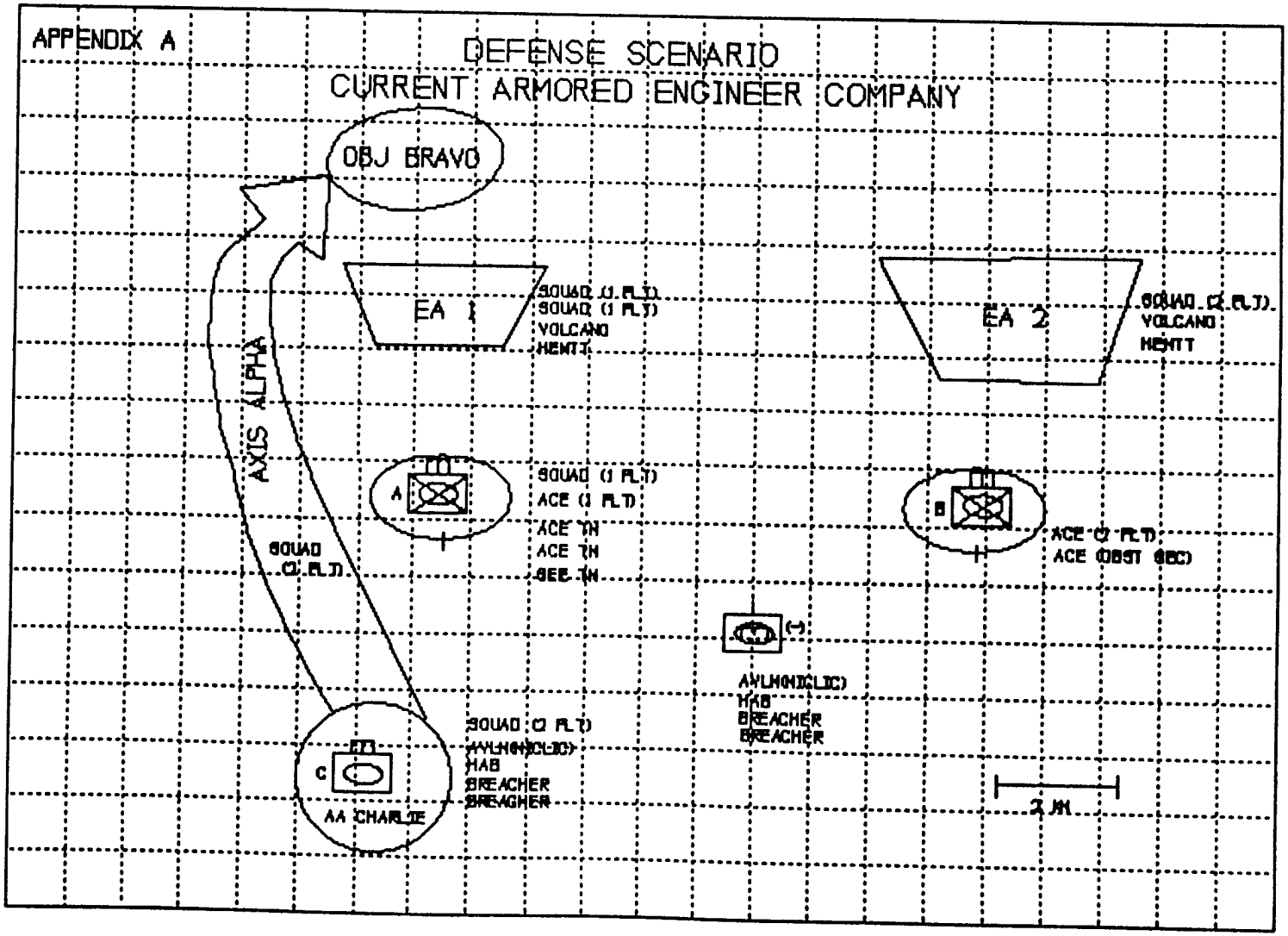
Future Research and Experimentation

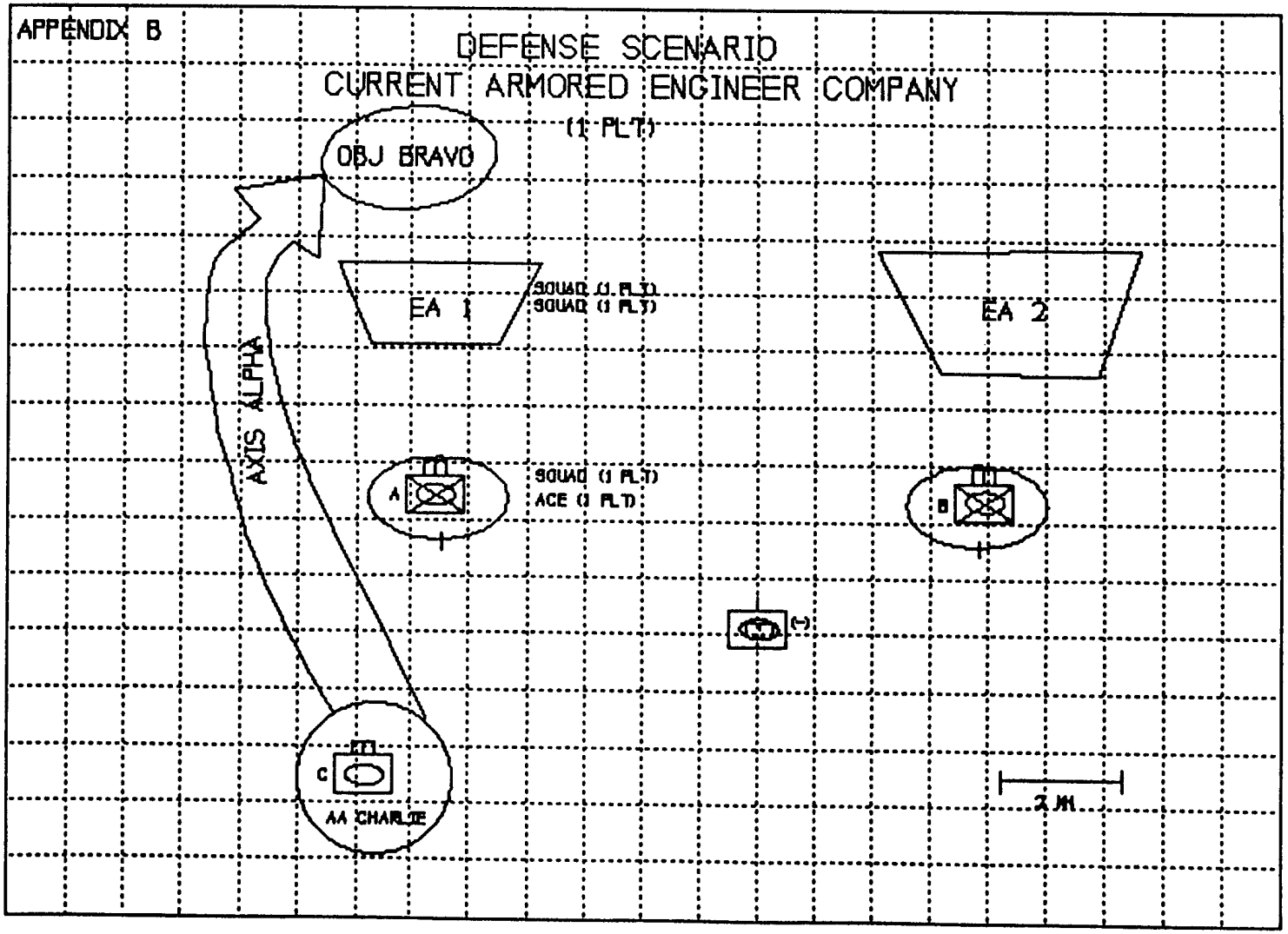
The evidence in this monograph is sufficient to indicate that there are some benefits to having a modular, capabilities-based Armored Engineer Battalion. But the limited analysis presented in this monograph does not conclusively prove that the U.S. Army Engineer Regiment should adopt a modular, capabilities-based Armored Engineer Battalion. Further research and experimentation, particularly with live simulations is needed. The evidence

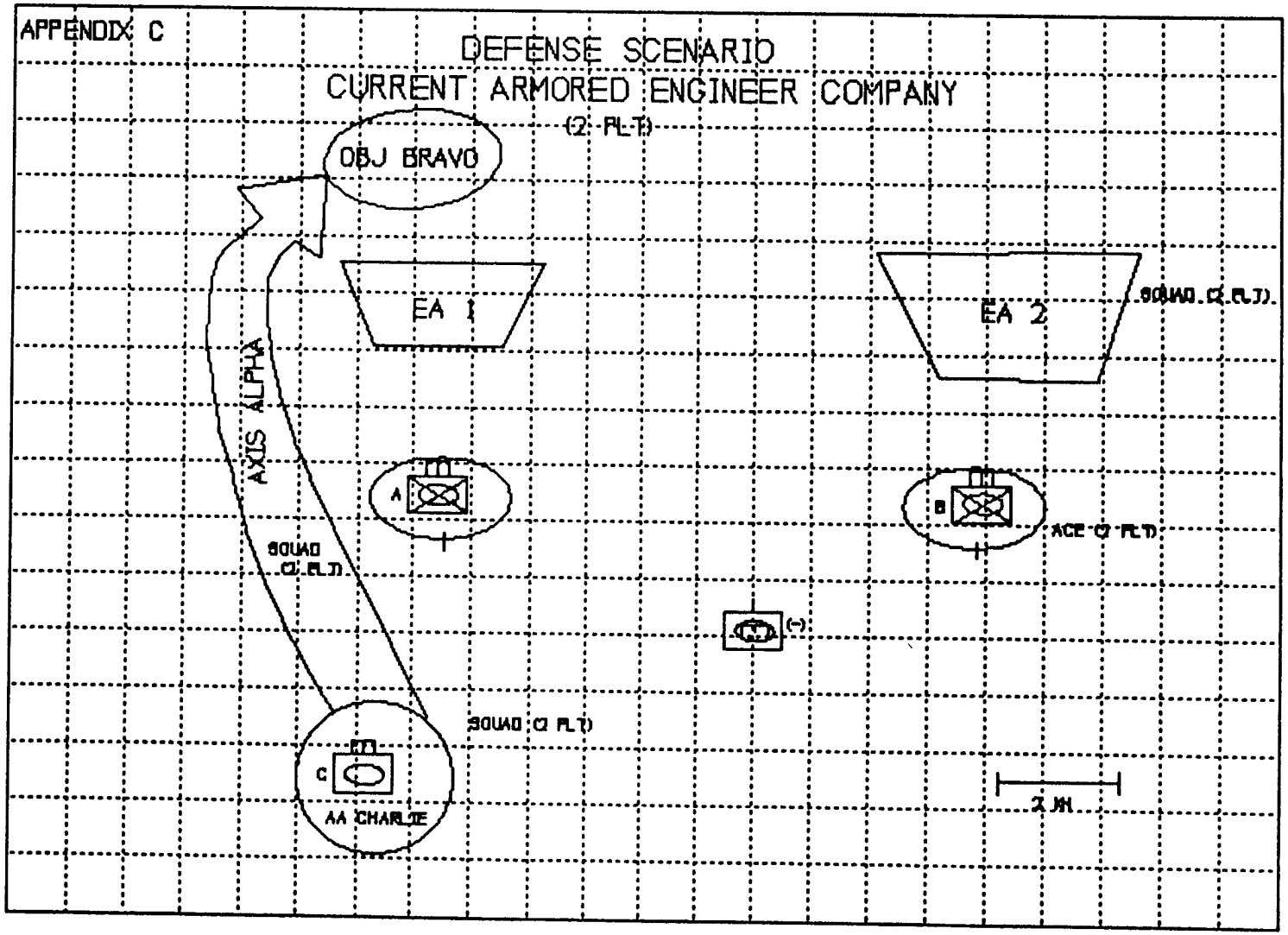
does suggest that a modular, capabilities-based Armored Engineer Battalion should be considered as one of the design alternatives for the future Armored Engineer Battalion.

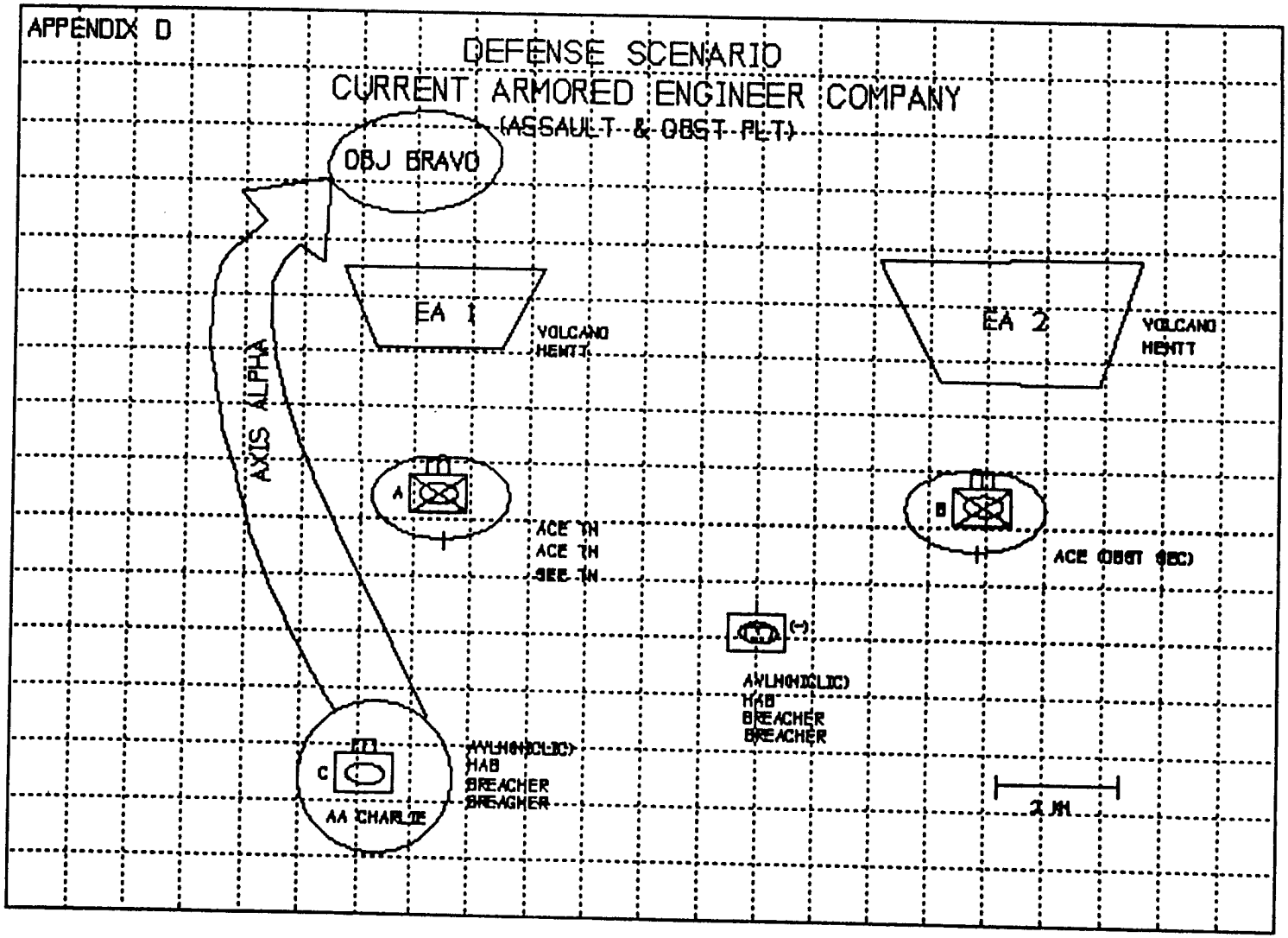
Conclusion

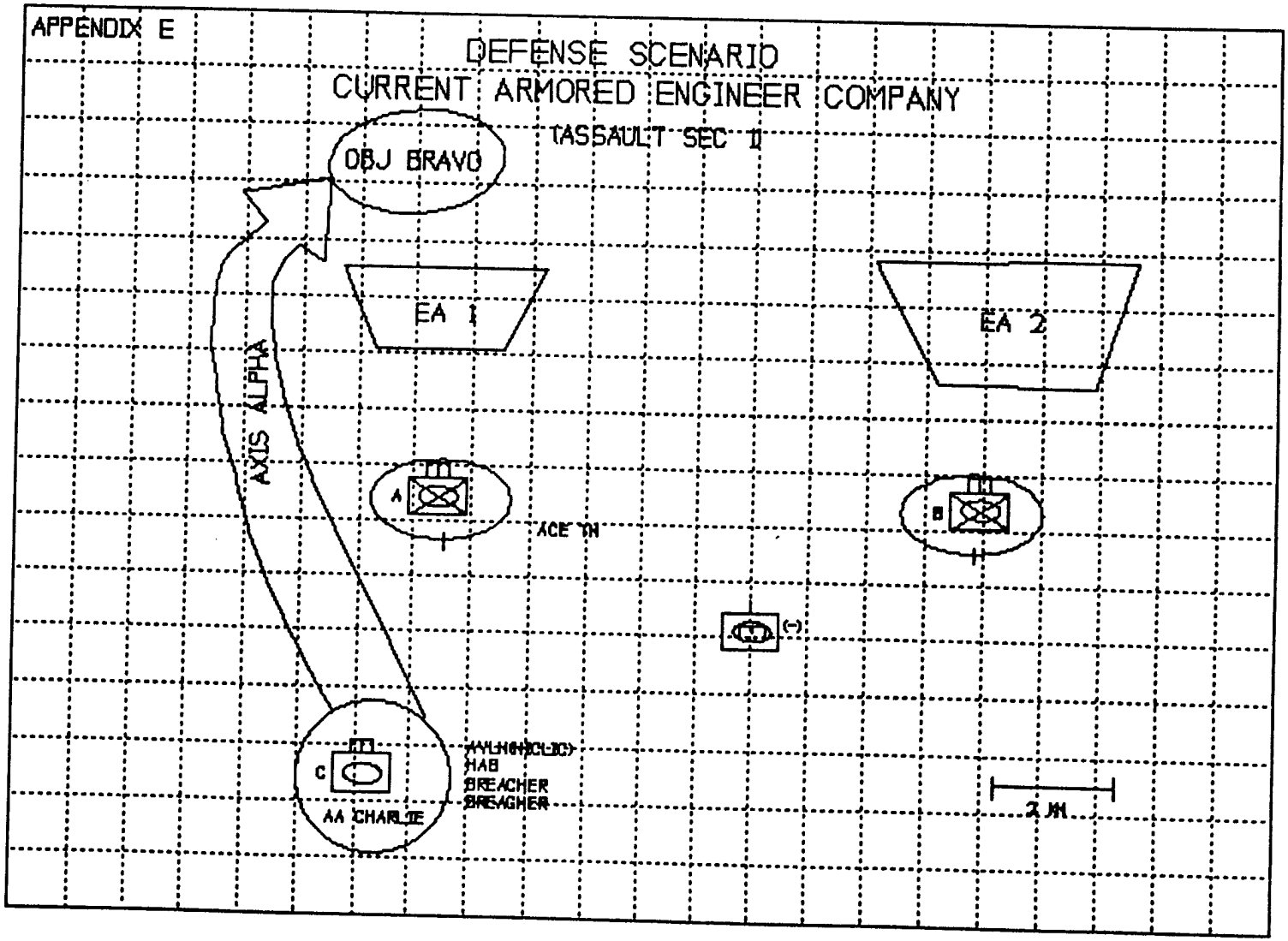
From the research and analysis presented in this monograph, an Armored Engineer Battalion organized around core battlefield missions would be more effective in supporting the Armored Brigade in full-dimensional operations than the Current Armored Engineer Battalion. A modular, capabilities-based Armored Engineer Battalion is better suited to the fast changing, dynamic, and unstable environment that can be expected in Force XXI operations. The tempo and battlespace of twenty-first century warfare will likely drive changes in the Current Armored Engineer Battalion organizational structure. The characteristics of future warfare may not allow the Armored Engineer Battalion the luxury to form temporary task forces (from different platoons and sections) to perform core battlefield missions. A modular, capabilities-based Armored Engineer Battalion organization may meet the demands of twenty-first century warfare. Using some words borrowed from Holder and Arnold "in the fluid, [dynamic, and unstable] conditions of [twenty-first century] warfare, a single well-drilled [modular, capabilities-based unit] is likely to fight better than a well-designed but new team."[82]

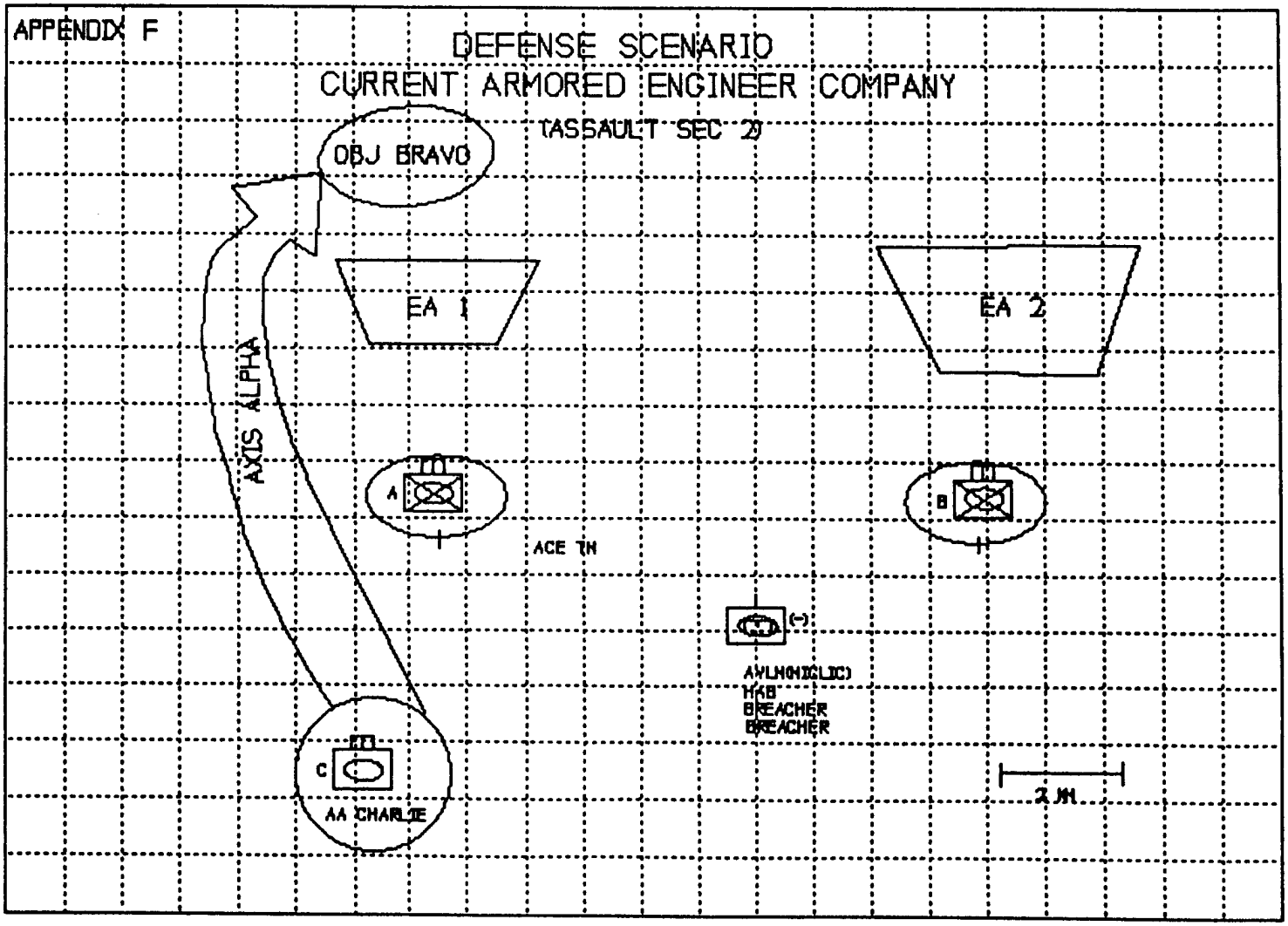

APPENDIX A
DEFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
OBJ BRAVO
EA 1
SQUAD (1 PLT)
SQUAD (1 PLT)
VOLCANO
HEMTT
EA 2
SQUAD (2 PLT)
VOLCANO
HEMTT
AXIS ALPHA
A
SQUAD (1 PLT)
ACE (1 PLT)
ACE TH
ACE TH
SQUAD
(2 PLT)
B
ACE (2 PLT)
ACE (OBST SEC)
(-)
AVLM(M)(CLIC)
HAB
BREACHER
BREACHER
C
SQUAD (2 PLT)
AVLM(M)(CLIC)
HAB
BREACHER
BREACHER
AA CHARLIE
2 KM

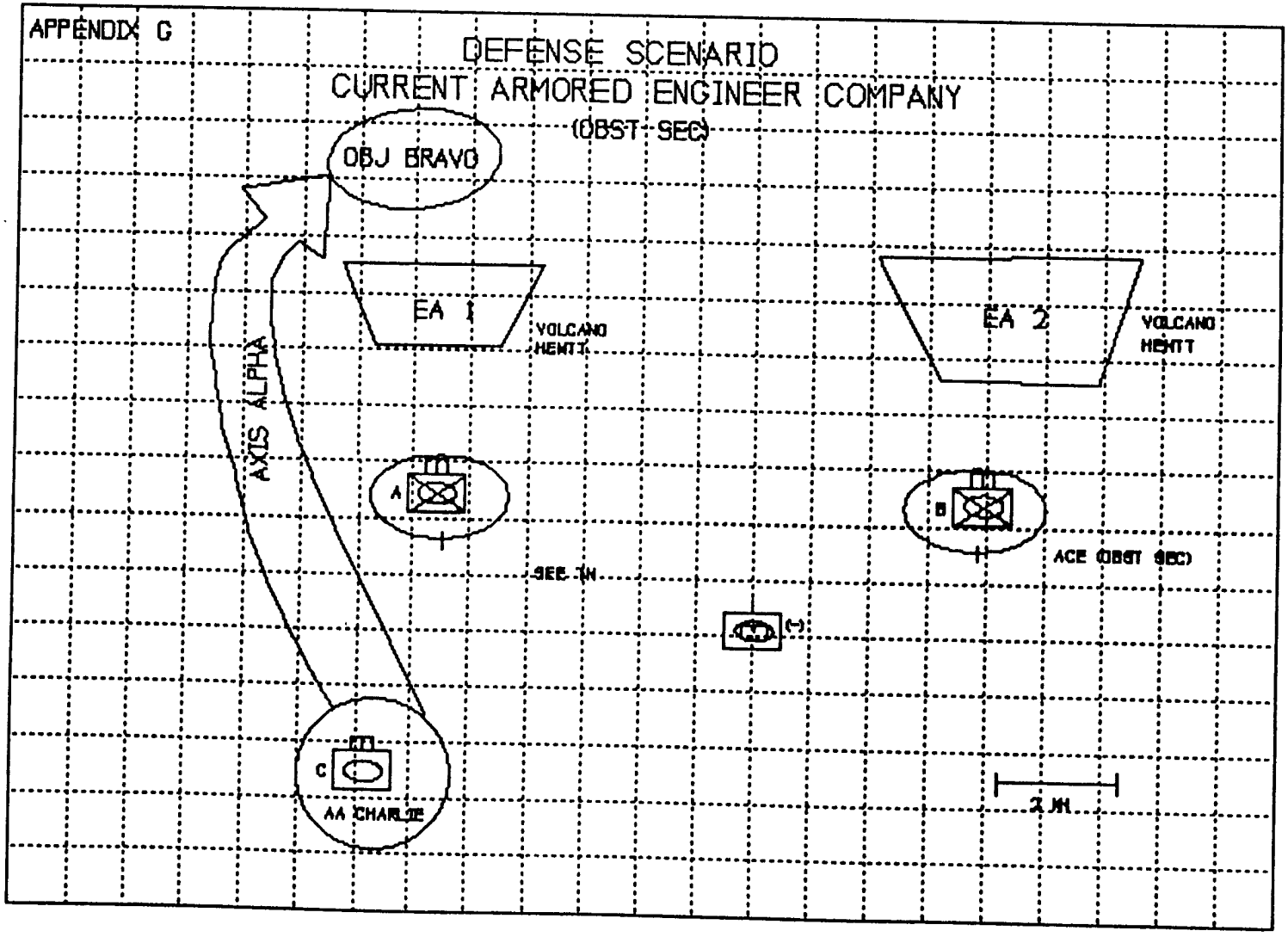

APPENDIX B
DEFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(1 PLT)
OBJ BRAVO
EA 1
SQUAD (1 PLT)
SQUAD (1 PLT)
EA 2
AXIS ALPHA
A
SQUAD (1 PLT)
ACE (1 PLT)
B
C
AA CHARLIE
2 KM

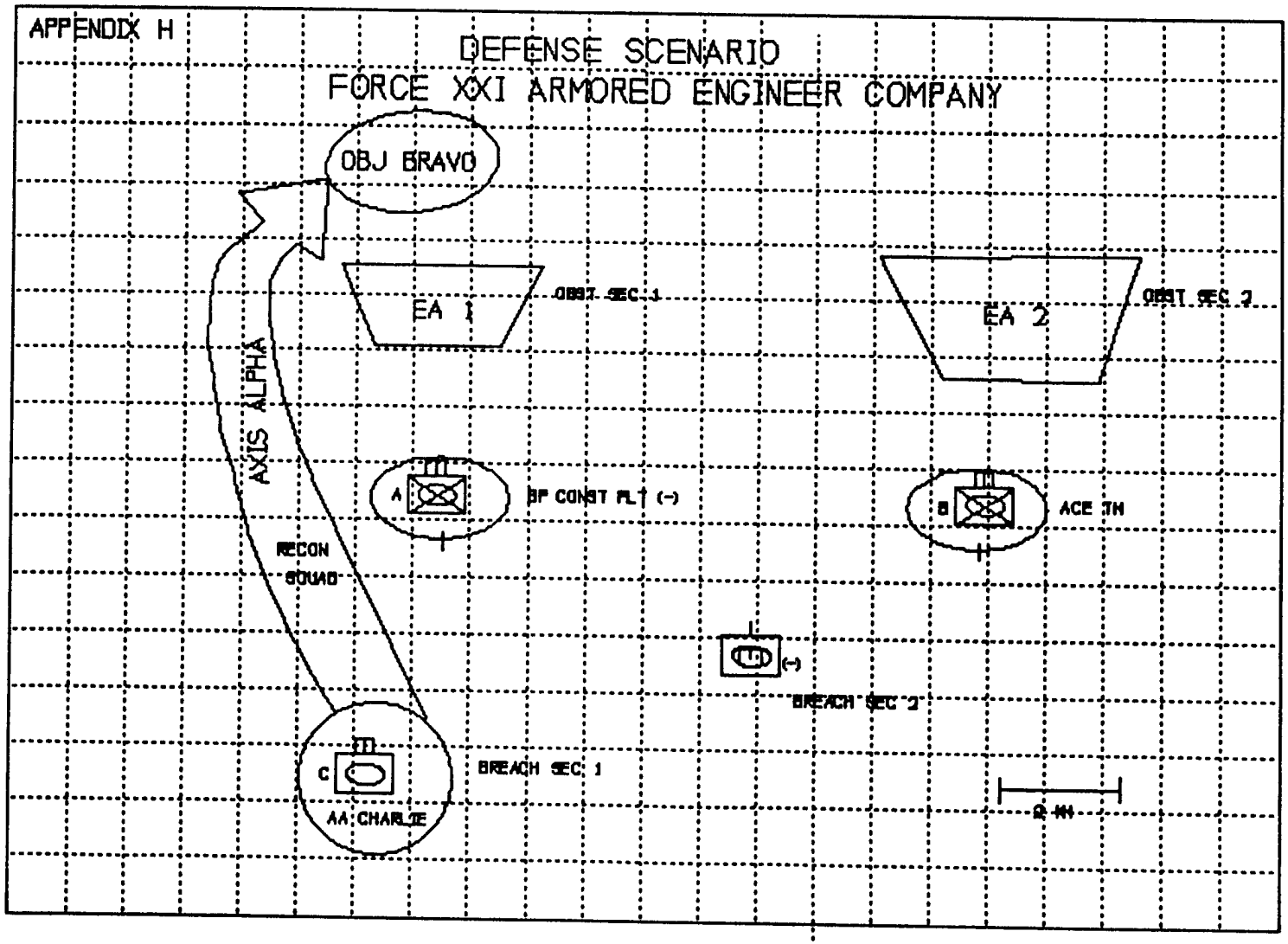

APPENDIX C
DEFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(2 PLT)
OBJ BRAVO
EA 1
EA 2
SQUAD (2 PLT)
AXIS ALPHA
A
B
SQUAD
(2 PLT)
ACE (2 PLT)
(-)
SQUAD (2 PLT)
C
AA CHARLIE
2 KM


APPENDIX D
DEFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(ASSAULT & OBST PLT)
OBJ BRAVO
EA 1
VOLCANO
HEMTT
EA 2
VOLCANO
HEMTT
AXIS ALPHA
A
ACE TM
ACE TM
SEE TM
B
ACE (OBST SEC)
(-)
AVLM(M)(LIC)
M/B
BREACHER
BREACHER
C
AA CHARLIE
AVLM(M)(LIC)
M/B
BREACHER
BREACHER
2 KM


APPENDIX E
DEFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
TASSAULT SEC II
OBJ BRAVO
EA 1
EA 2
AXIS ALPHA
A
ACE TM
B
(-)
C
AA CHARLIE
HAB
BREACHER
BREACHER
2 KM

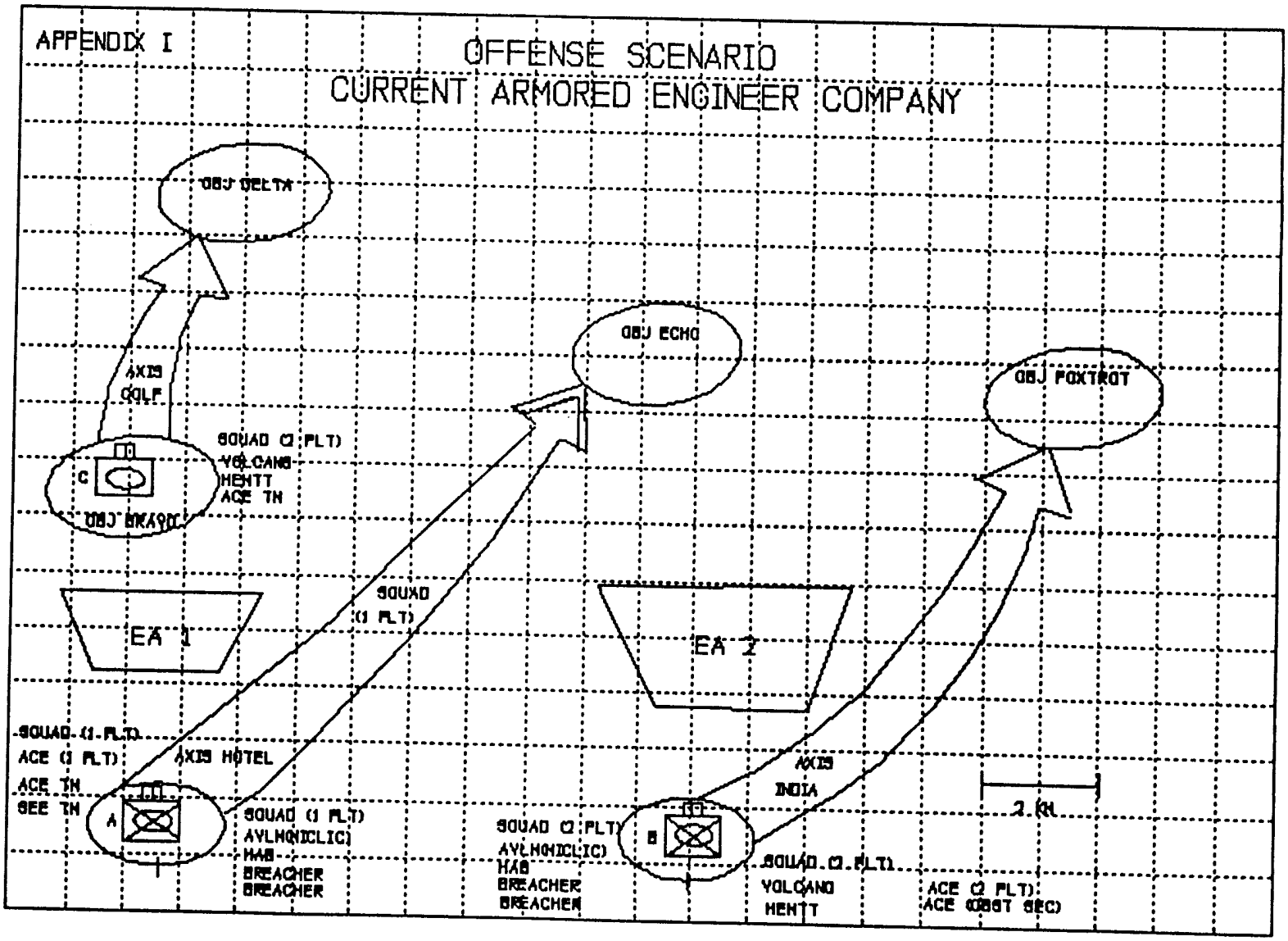

APPENDIX F
DEFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
TASSAULT SEC 20
OBJ BRAVO
EA 1
EA 2
AXIS ALPHA
A
B
C
ACE TM
AA CHARLIE
2 KM

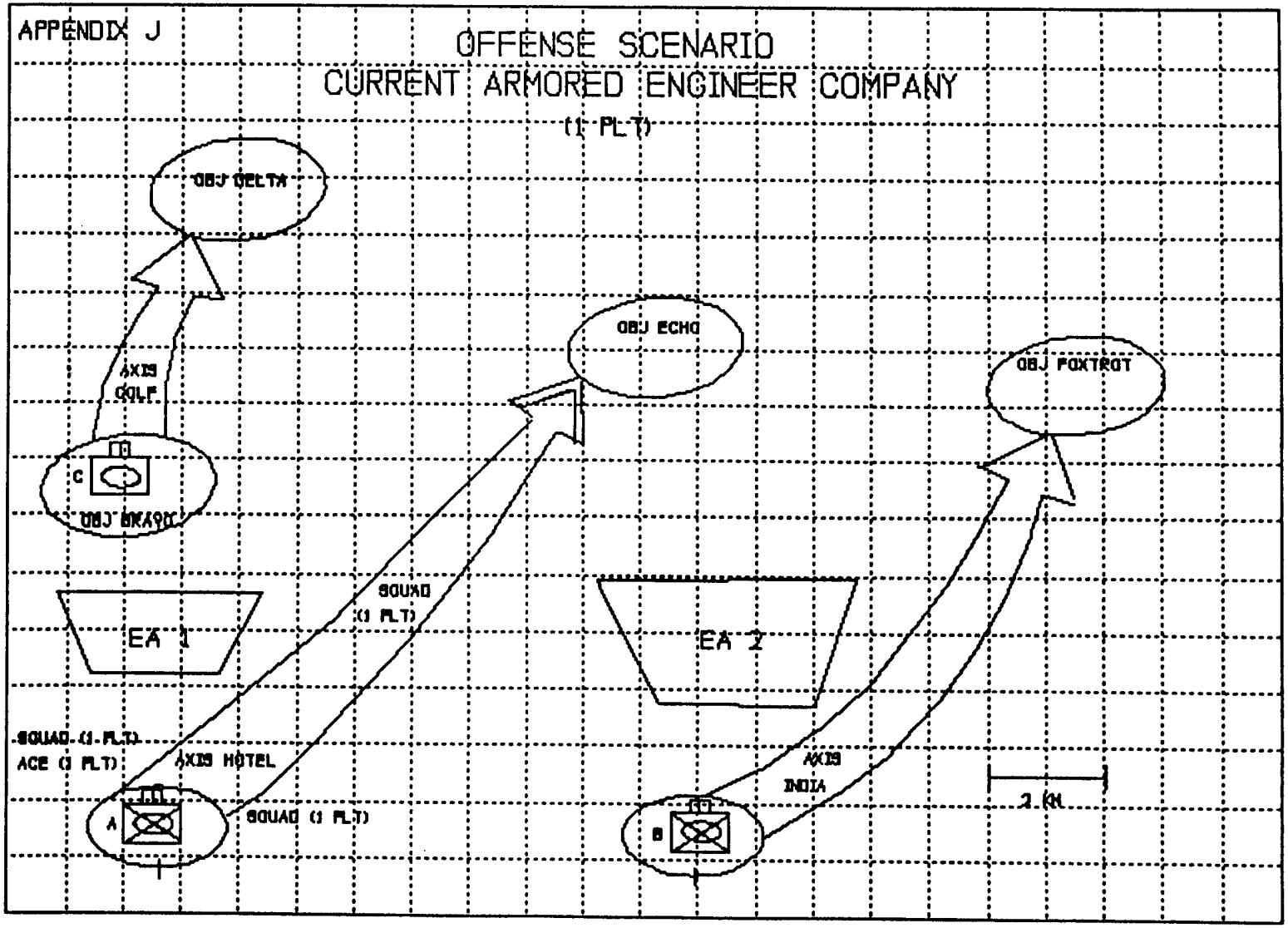

APPENDIX G
DEFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(OBST SEC)
OBJ BRAVO
EA 1
VOLCANO HEIGHTS
EA 2
VOLCANO HEIGHTS
AXIS ALPHA
A
B
ACE (OBST SEC)
SEE IN
C
AA CHARLIE
2 KM

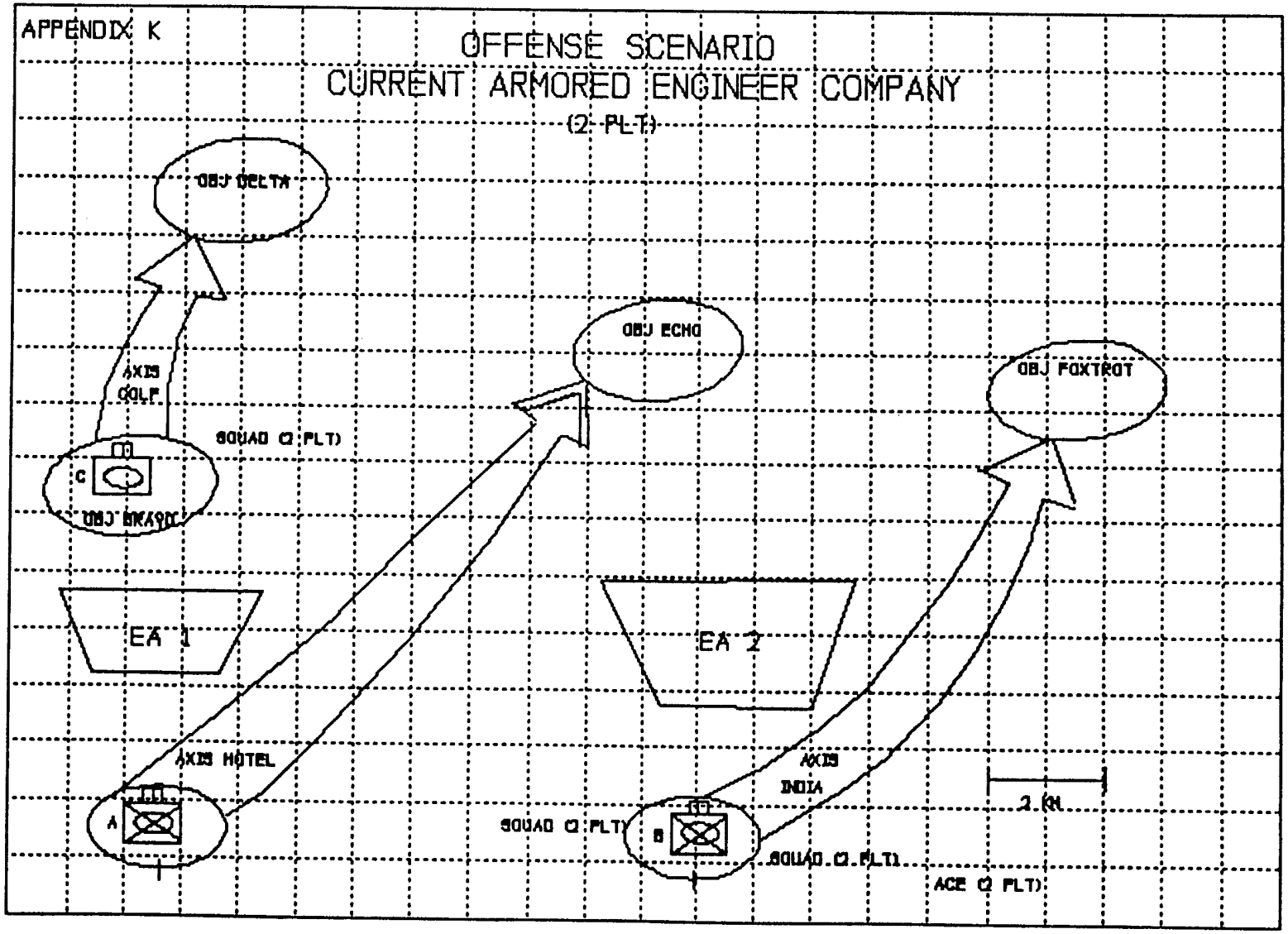

APPENDIX H
DEFENSE SCENARIO
FORCE XXI ARMORED ENGINEER COMPANY
OBJ BRAVO
EA 1
OBST SEC 1
EA 2
OBST SEC 2
AXIS ALPHA
A
BP CONST PLT (-)
B
ACE TM
RECON
SQUAD
(-)
BREACH SEC 2
C
BREACH SEC 1
AA: CHARLIE
0 M

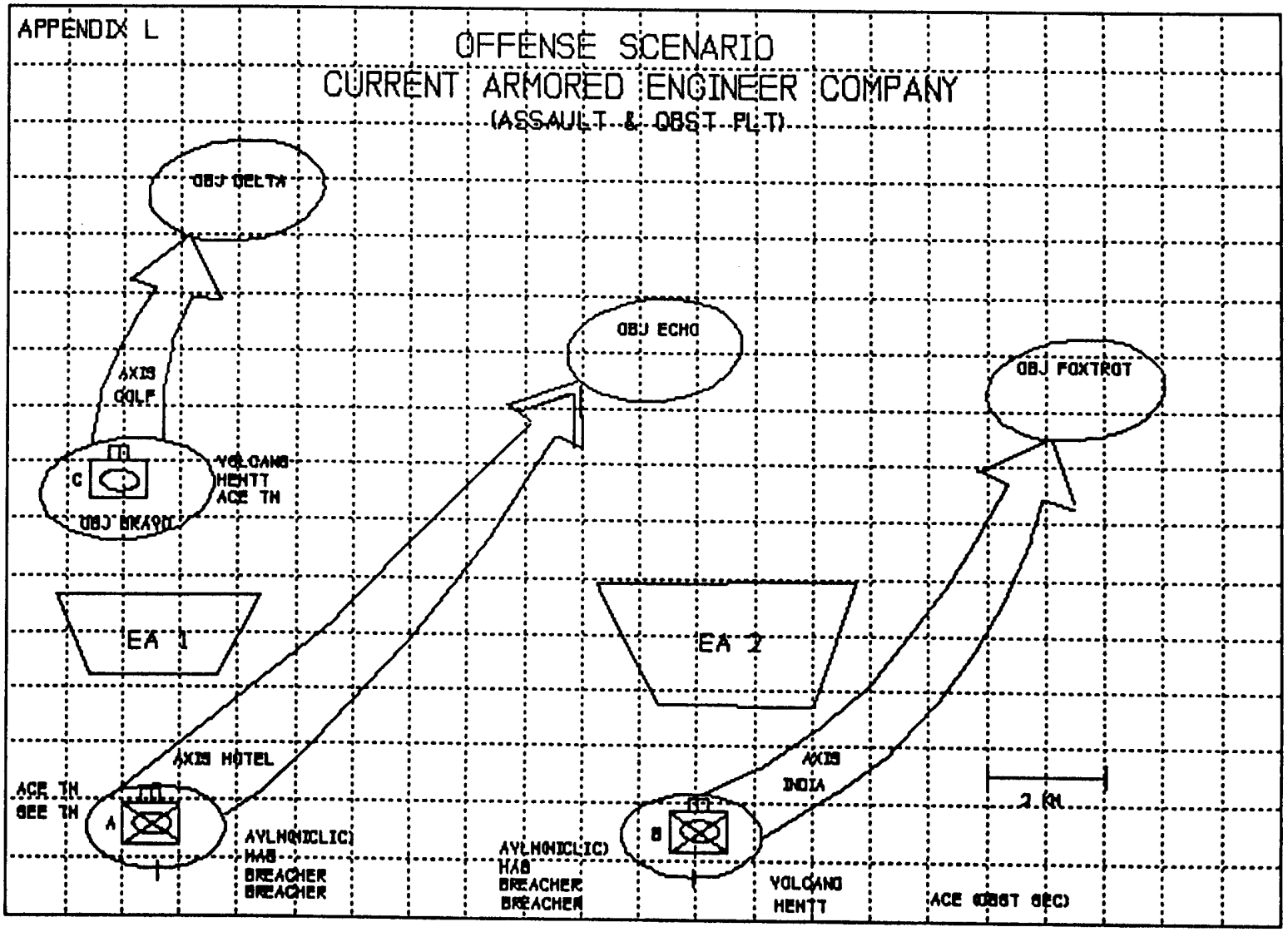
APPENDIX I

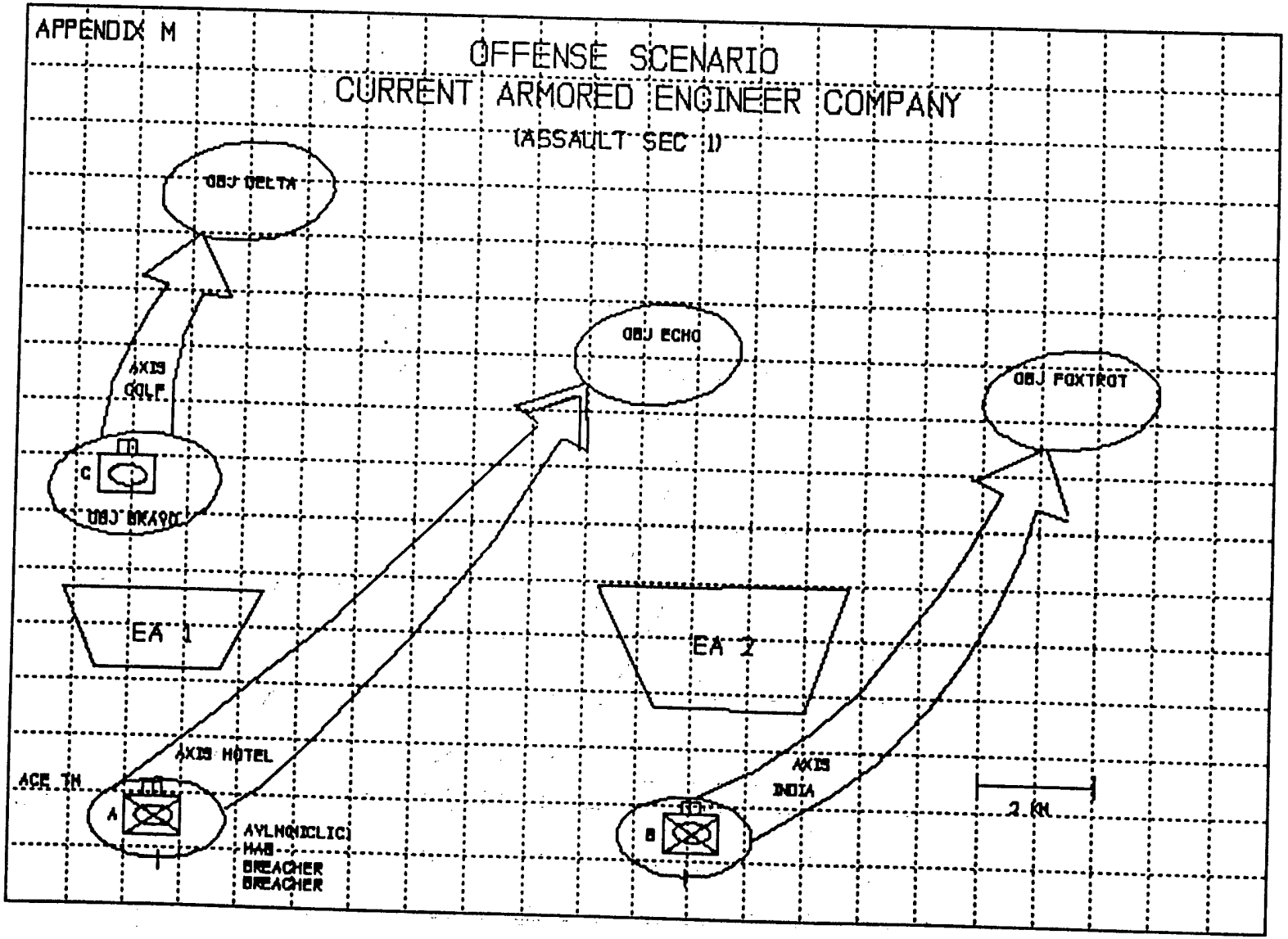
OFFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY




APPENDIX J
OFFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(1 PLT)
OBJ DELTA
OBJ ECHO
OBJ FOXTROT
AXIS
GOLF
C
OBJ BRAVO
EA 1
EA 2
SQUAD
(1 PLT)
SQUAD (1 PLT)
ACE (1 PLT)
AXIS HOTEL
A
SQUAD (1 PLT)
AXIS
INDIA
B
2 KM

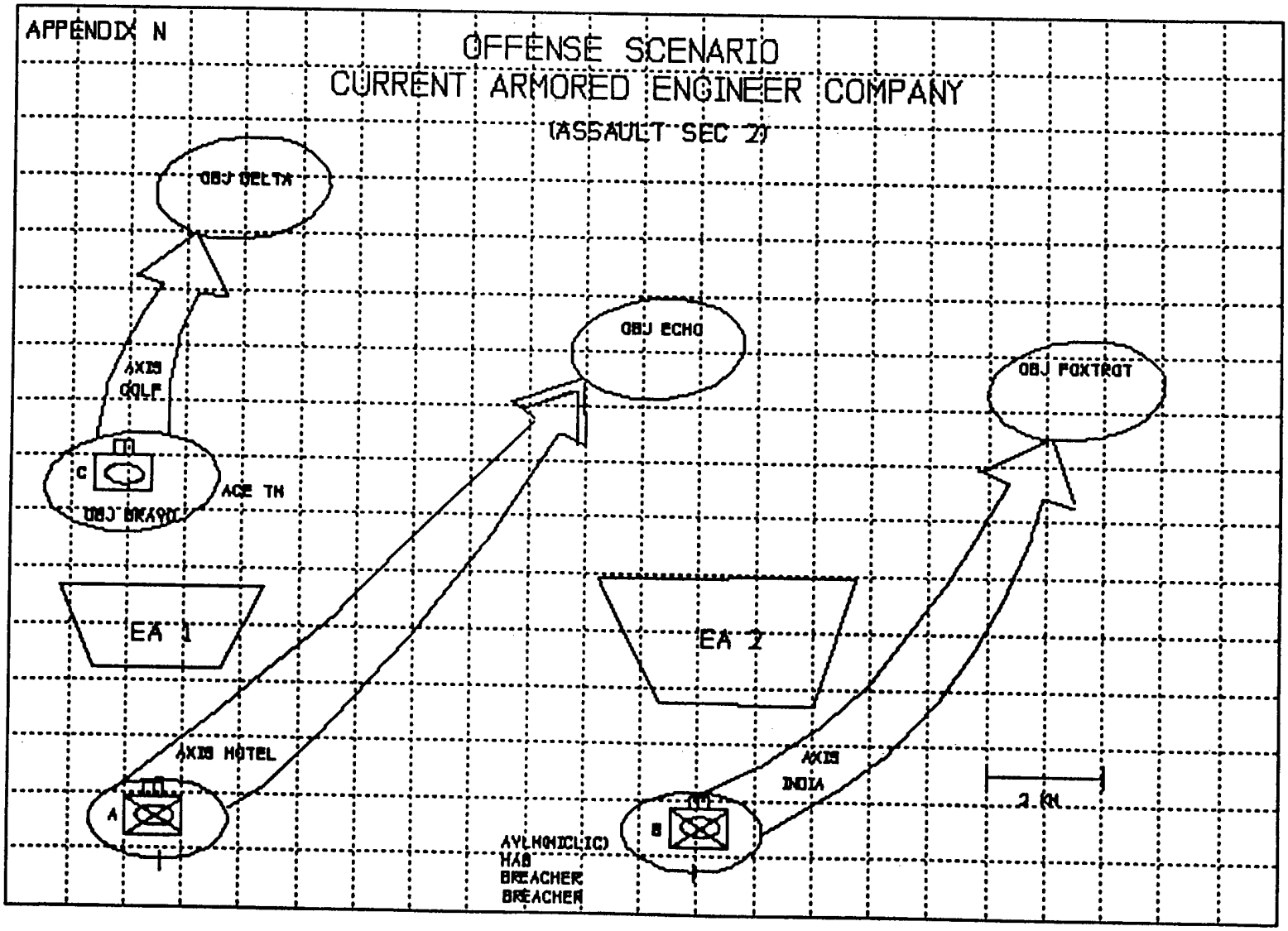

APPENDIX K
OFFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(2 PLT)
OBJ DELTA
OBJ ECHO
OBJ FOXTROT
AXIS GOLF
SQUAD (2 PLT)
C
OBJ BRAVO
EA 1
EA 2
AXIS HOTEL
A
AXIS INDIA
SQUAD (2 PLT)
B
SQUAD (2 PLT)
ACE (2 PLT)
2 KM

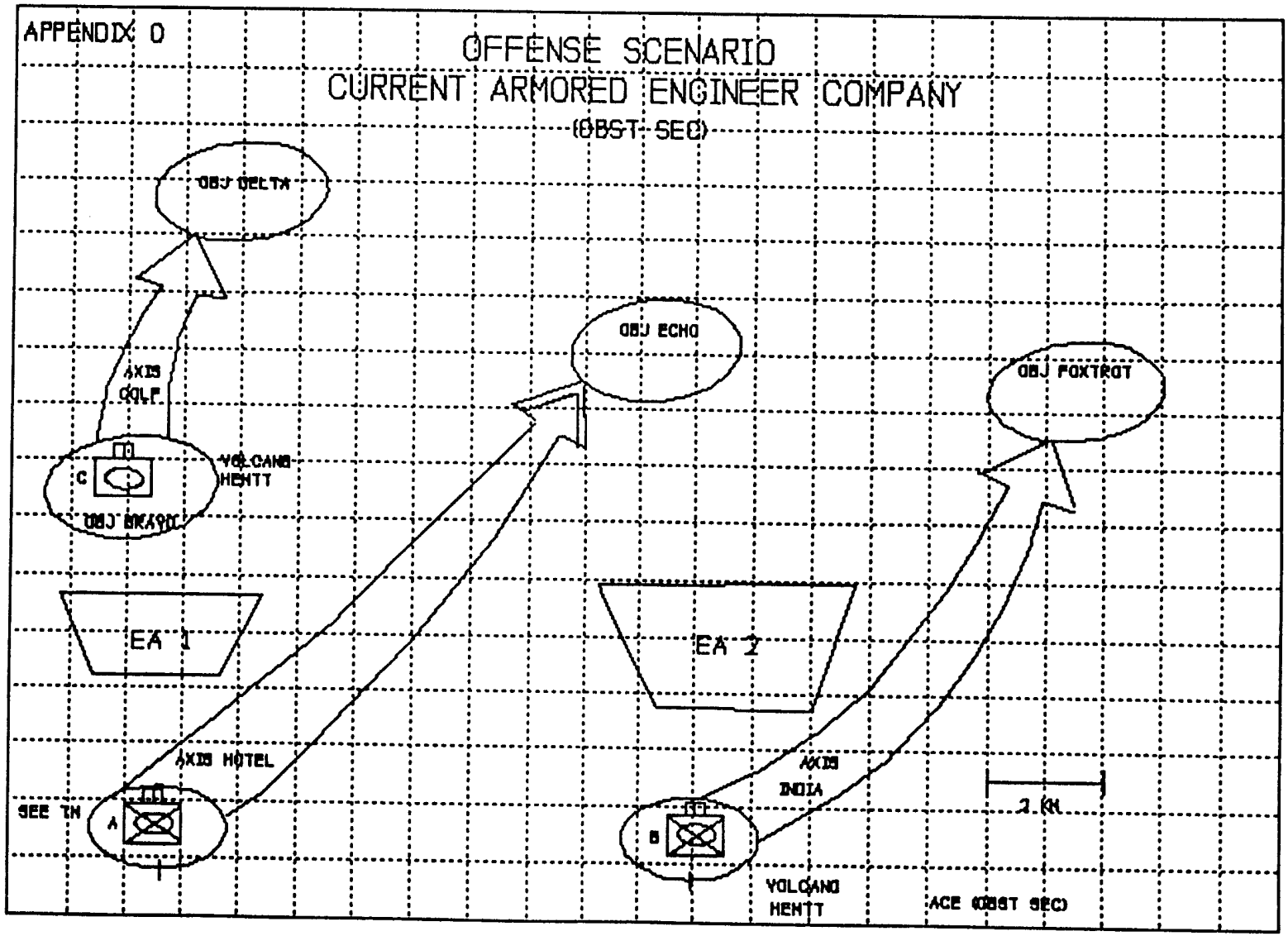

APPENDIX L
OFFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(ASSAULT & OBST PLT)
OBJ DELTA
OBJ ECHO
OBJ FOXTROT
AXIS GOLF
C
VOLCANO
HENTT
ACE TM
OBJ BRAVO
EA 1
EA 2
AXIS HOTEL
ACE TM
SEE TM
A
AVLNCHCLIC
HAB
BREACHER
BREACHER
AVLNCHCLIC
HAB
BREACHER
BREACHER
B
AXIS
INDIA
VOLCANO
HENTT
2 KM


APPENDIX M
OFFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(ASSAULT SEC 1)
OBJ DELTA
OBJ ECHO
OBJ FOXTROT
AXIS GOLF
C
OBJ BRAVO
EA 1
EA 2
AXIS HOTEL
ACE IN
A
AVLB(MIC)LIC)
MAB
BREACHER
BREACHER
AXIS INDIA
B
2 KM

APPENDIX N

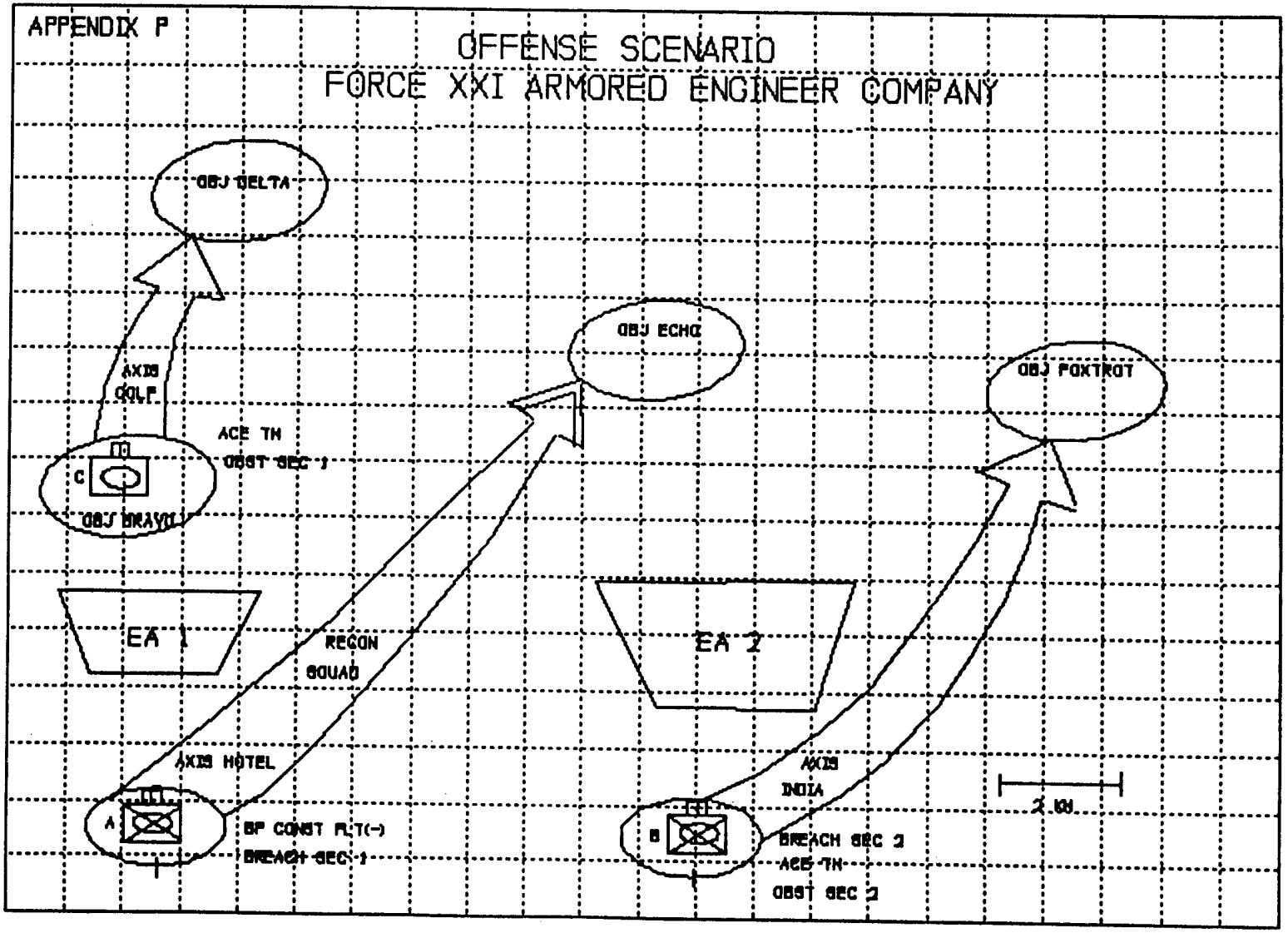
OFFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(ASSAULT SEC 2)




APPENDIX O
OFFENSE SCENARIO
CURRENT ARMORED ENGINEER COMPANY
(OBST SEC)
OBJ DELTA
OBJ ECHO
OBJ FOXTROT
AXIS GOLF
VOLCANO HENTT
C
OBJ BRAVO
EA 1
EA 2
AXIS HOTEL
SEE TM
A
AXIS INDIA
B
VOLCANO HENTT
2 KM
ACE (OBST SEC)

APPENDIX P

OFFENSE SCENARIO
FORCE XXI ARMORED ENGINEER COMPANY



APPENDIX Q

GLOSSARY

Battlespace - Components of this space are determined by the maximum capabilities of friendly and enemy forces to acquire and dominate each other by fires and maneuver and in the electromagnetic spectrum.[83]

Force Projection - The movement of military forces from CONUS or a theater in response to requirements of war or operations other than war; force-projection operations extend from mobilization and deployment of forces, to redeployment to CONUS or home theater, to subsequent demobilization.[84]

Full-dimensional Operations - The application of all capabilities available to an Army commander to accomplish his mission decisively and at the least cost across the full range of possible operations.[85]

Information Operations - Continuous combined arms operations that enable, enhance, and protect the commander's decision cycle and execution while influencing an opponent's; operations are accomplished through effective intelligence, command and control, and command and control warfare operations, supported by all available friendly information systems; battle command information operations are conducted across the full range of military operations.[86]

Modular Designed Elements (Modularity) - Organizations constructed with discrete elements of specific capabilities. The elements are specific parts/elements of the organization and, when combined, create the functional capability of the unit. each subordinate element does not mirror the functional capability of the entire unit.[87]

Satisficed - a modification of the word satisficing. Satisficing is defined as "don't aim for optimization, aim for good enough."[88]

Tailorability - Capability to determine the right mix and sequencing of units with sufficient combat power to accomplish the mission and sustain the force, based on METT-T, analysis, and other criteria such as available lift, pre-positioned assets and host nation support.[89]

APPENDIX R

ABBREVIATIONS

AA	Assembly Area
ACE	Armored Combat Earthmover
ASLT	Assault
AVLM	Armored Vehicle Launched MICLIC
AWE	Advanced Warfighting Experiment
BDE	Brigade
BN	Battalion
BP	Battle Position
CBT	Combat
CO	Company
CONST	Construction
CONUS	Continental United States
DIV	Division
EA	Engagement Area
EN	Engineer
SQD	Squad
HAB	Heavy Assault Bridge
HEMTT	Heavy Expanded Mobility Tactical Truck
HHC	Headquarters and Headquarters Company
HQ	Headquarters
HVY	Heavy
KM	Kilometer
LOGPAC	Logistics Support Package
MAINT	Maintenance
MECH	Mechanized
MICLIC	Mine Clearing Line Charge
OBJ	Objective
OBST	Obstacle
PLT	Platoon

PSG	Platoon Sergeant
RECON	Reconnaissance
SEC	Section
SEE	Small Equipment Excavator
TM	Team
TOE	Tables of Organization and Equipment
TRADOC	U.S. Army Training and Doctrine Command
UMCP	Unit Maintenance Collection Point
XO	Executive Officer
1SG	First Sergeant

APPENDIX S

COMMENTS

1. What difference does it make how the TOE is organized? The commander will organize the unit how he needs to.

The Force XXI Armored Engineer Battalion organization highlights numerous material shortfalls that are not readily apparent in the current TOE. For example: The engineer reconnaissance squad needs a vehicle (or vehicles) that can be integrated in with the a maneuver battalion scout platoon and enhanced optical and position locating devices; and all of the breaching platoon's vehicles need to be equipped with thermal sights/viewers so that the platoon can perform its mission in smoke and obscurants.

2. Doesn't a modular, capabilities-based engineer battalion have less versatility. Each platoon is designed to accomplish only one task.

A modularizing an engineer battalion does not decrease the capabilities or versatility of the battalion. No change is made to the resources available to the commander. A modular, capabilities-based engineer battalion just transforms platoons that are jacks-of-all-trades, masters of none to platoons that are jacks-of-all-trades, masters of one.

3. A modular, capabilities-based engineer battalion will hinder the engineer battalion in reorganizing to fight as infantry.

Reorganizing an engineer battalion to fight as infantry is simply that - a reorganization. The modular, capabilities-based engineer battalion does not decrease the warfighting capabilities available in the Armored Engineer Battalion and does not significantly unbalance the fighting as infantry potential of the engineer platoons.

4. A modular, capabilities-based engineer battalion will make it more difficult to support dismounted infantry.

The same number of engineers squads are available to support dismounted infantry in the modular, capabilities-based engineer battalion as in the Current Armored Engineer Battalion.

6. The modular, capabilities-based engineer battalion will make it more difficult to train combat engineer vehicle crewmen (12 F) and combat engineers (12 B) since they are intermingled in the same platoon.

The military occupational specialties of 12 F (combat engineer vehicle crewman) and 12 B (combat engineer) are being consolidated so there are training benefits from intermingling vehicle crewmen and combat engineers in the same platoon.

7. The modular, capabilities-based engineer battalion will make it more difficult to perform operations other than war (OOTW).

It is no more difficult for a modular, capabilities-based engineer battalion to form internal, temporary task forces to perform OOTW missions than for the current armored engineer battalion to form internal, temporary task forces to perform missions in OOTW.

ENDNOTES

1. U.S. Army Training and Doctrine Command. *TRADOC Pamphlet 525-5, Force XXI Operations,* (Ft. Monroe, VA., August 1994), 2-8.

2. Ibid, Chapter 3.

3. Ibid., iii.

4. Observed by the author. The author was a member of the engineer data collection/observer team for the following U.S. Army Advanced Warfighting Experiments (AWEs): Desert Hammer VI; Focused Dispatch; Mobile Strike Force 95. The author was also a student participant in the Mobile Strike Force 96 AWE.

5. The core battlefield missions were defined by the author and directly correlates to the 4 engineer battlefield functions of mobility, countermobility, survivability, and topographic engineering which is typically found at the maneuver brigade level. These functions are described in the 1996 version of FM 5-100, *Engineer Operations.*

6. John E. Miller, "Force XXI - Vision for Change," *Military Review,* (May-June 1995), 1.

7. The Current Armored Engineer Company is organized in accordance with Table of Organization and Equipment 053351000 (Objective) dated February 2, 1996. The M-1 Breacher (Grizzly) and the Heavy Assault Bridge (Wolverine) were added to the organization because they are projected to be fielded early in the twenty-first century.

8. *TRADOC Pamphlet 525-5, Force XXI Operations; TRADOC Pamphlet 525-XX, Force XXI Divisional Operations Concept; TRADOC Pamphlet 525-68, Concept for Modularity and the Force XXI Design Principles* (see note 6).

9. Peter J. Taylor, *Quantitative Methods in Geography,* (Prospect Heights, IL: Waveland Press, Inc., 1983), 37-82.

10. U.S. Army Training and Doctrine Command Analysis Center. *Study Plan TRAC-SP-November 1995, Force XXI Division Redesign Analysis* (Ft. Leavenworth, KS., November 1995).

11. The scenarios were partly developed from the authors experience with recent AWEs.

12. William Morris, The American Heritage Dictionary, (New York: American Heritage Publishing Company, 1969), 433.

13. Paul K. Walker, *Engineers of Independence*, (Washington, D.C.: Office of the Chief of Engineers, undated), 29-250.

14. See *Engineers in Battle* by Paul Thompson; *The U.S. Army Engineers - Fighting Elite*, edited by Franklin M. Davis, Jr., and Thomas T. Jones; *Engineers of Independence* by Paul K. Walker.

15. This definition was formulated by the author based on over 15 years of experience as a Combat Engineer.

16. Department of the Army, *Field Manual 5-100, Engineer Operations*, (Washington, D.C., November 22, 1988), 9.

17. John Kegan and Richard Holmes, *Soldiers, A History of Men in Battle*, (London: Hamish Hamilton Ltd., 1985), 163.

18. U.S. Army Armor School, *Operations of the Armored Engineers in the European Theater of Operations*, (Ft. Knox, KY., 1950), 7.

19. Department of the Army, *Field Manual 5-104, General Engineering*, (Washington, D.C., November 12, 1986), 1.

20. Richard L. Daft, *Organization Theory and Design*, (New York: West Publishing Company, 1989), 226.

21. Ibid., 230.

22. Ibid., 227.

23. Ibid.

24. Ibid.

25. Ibid., 232.

26. Joseph Schroedel, *Tactical Mobility: Organizing Engineers for an All Arms Problem,* (Ft. Leavenworth KS: School of Advanced Military Studies Monograph, 1987), 13.

27. Foreign Broadcast Information Service, *JPRS-UMA-85-020-L, USSR Report - Combat Engineer Support* (August 26, 1985).

28. Schroedel, 12.

29. The organizational chart was constructed based on information provided to the author during a meeting with Mr. Dorian D'Aria at Ft. Leonard Wood, MO. on July 11, 1996. Mr. D'Aria is currently the U.S. Army Engineer School's subject matter expert on threat engineer organizations.

30. Department of the Army, *Field Manual 100-2-1, The Soviet Army Operations and Tactics,* (Washington, D.C., July 16, 1984), 14-1 through 14-6.

31. Schroedel, 15-19.

32. U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-5,* 2-9.

33. Ibid., 3-19.

34. Ibid., 4-5.

35. Ibid.

36. Ibid.

37. Ibid.

38. U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-XX, Force XXI Division Operations Concept (Draft),* (Ft. Monroe, VA., February 7, 1995), 28.

39. U.S. Army Training and Doctrine Command. *TRADOC Pamphlet 525-68, Concept for Modularity,* (Ft. Monroe, VA., August 1994), 5.

40. Miller, 1.

41. The author served in the 10th Armored Engineer Battalion from December 1993 to December 1996. The 10th Armored Engineer Battalion was commanded by LTC Russell L. Fuhrman when the modular, capabilities-based engineer units were formed.

42. The author was one of seven engineer students who were enrolled in the Battle Command Elective during the 1995/96 U.S. Army Command and General Staff Officer Course.

The author served as the Mobile Strike Force engineer plans officer during the Mobile Strike Force 96 Advanced Warfighting Experiment conducted at Fort Leavenworth, Kansas in the Spring of 1996.

43. Personal observation by the author.

44. Personal observation by the author.

45. Mr. Richard Schuler, Battle Command Training Program Engineer Analyst employed by the LOGICON Corporation, interview by author, August 3, 1996, Ft. Leavenworth, KS.

46. U.S. Army Armor School, *Operations of the Armored Engineers in the European Theater of Operations,* (Ft. Knox, KY., 1950), 15.

47. John A. English, *On Infantry,* (New York: Praeger Publishers, 1984), 130-132.

48. Richard S. Kem, J. Richard Capka, and Houng Y. Soo, "E-Force." *Engineer*, Spring 1986. 6-13.

49. Clair F. Gill, "Interview: Major General Clair Gill, Commander, U.S. Army Engineer Center and Fort Leonard Wood," interview by *Army Times*, December 2, 1996.

50. Romjue, John L. *From Active Defense to AirLand Battle: The Development of Army Doctrine 1973-1982,* (Ft. Monroe, VA: Historical Office, U.S. Army Training and Doctrine Command, June 1984).

51. Kem, Richard S., J. Richard Capka, and Houng Y. Soo, "E-Force an Update." *Engineer*, (July 1988). 10-19

52. Miller, 1.

53. See note 5.

54. Daft, 226-233.

55. Ibid., 226-230.

56. Ibid., 230-233.

57. Ibid., 230-232.

58. Ibid.

59. Department of the Army, *Field Manual 25-101, Battle Focused Training,* (Washington, D.C., September 30, 1990), 1-10.

60. Department of the Army, *Field Manual 25-100, Training the Force,* (Washington, D.C., November 15, 1988), 1-3 ff.

61. Ibid., 1-3.

62. Personal observation by the author.

63. Department of the Army, *Field Manual 20-32, Mine/ Countermine Operations,* (Washington, D.C., August 17, 1994), 6-23 through 6-31.

64. Department of the Army, *Field Manual 90-13-1, Combined Arms Breaching Operations,* (Washington, D.C., May 7, 1993), 2-3 through 2-4.

65. Department of the Army. *Field Manual 5-10, The Engineer Platoon (Coordinating Draft),* (U.S. Army Engineer School, 1995), 34.

66. See note 5.

67. Department of the Army, *Field Manual 25-100,* 1-3 and 1-4.

68. Ibid., 1-4.

69. Ibid.

70. Ibid.

71. Lieutenant Colonel Stephen Wood, Mobility Branch Chief, Directorate of Combat Developments, U.S. Army Engineer School, 1992 and 1993, interview by author, 5 October 1996, Ft. Leavenworth, KS.

72. Department of the Army, *Field Manual 25-100,* 1-5.

73. Personal observation by the author.

74. Daft, 230-232.

75. Mr. Dorian D'Aria, U.S. Army Engineer School's subject matter expert on threat engineer organizations, at Ft. Leonard Wood, MO., interview by author, July 11, 1996.

76. It is the author's opinion that when battlespace increases for an Armored Engineer unit, unit effectiveness decreases. Command and control, logistics support, unit morale, and responsiveness of Armored Engineers are negatively affected when the physical dimensions of the battlefield increase. Armored Engineers have almost no stand-off distances and must physically mass personnel and

equipment at a point on the battlefield to achieve the desired effects. Because of this, the massing, supplying, and controlling of Armored Engineers and their equipment becomes more difficult when battlespace increases. This opinion was formed after reading The *Evolution of Modern Land Warfare* and the *Future of Modern Land Warfare* by Christopher Bellamy.

77. Stan Arnoff, *Geographic Information Systems: A Management Perspective,* (Ottawa, Canada: WDL Publications, 1989), 1-27.

78. Kevin Kelly, *Out of Control,* (New York: Addison-Wesley, 1994), 1-4.

79. Major Michael Presnell, Combined Maneuver Training Center Observer/Controller from 1993 through 1995., interview by author, 23 July 96, Leavenworth, KS.

80. S.L.A. Marshall, *Men Against Fire,* (Glouchester, MS: Peter Smith, 1978), 154.

81. Kelly, 470.

82. L.D. Holder, and Edwin J. Arnold, "Moving the Heavy Division," *Military Review,* (July 1988), 38.

83. U.S. Army Training and Doctrine Command. *TRADOC Pamphlet 525-5,* G-1.

84. Ibid., G-4.

85. Ibid.

86. Ibid.

87. U.S. Army Training and Doctrine Command. *TRADOC Pamphlet 525-68,* 4.

88. Kelly, 199.

89. U.S. Army Training and Doctrine Command. *TRADOC Pamphlet 525-5,* G-7.

BIBLIOGRAPHY

Books

Aganov, S., *Engineer Support*. Charlottesville, VA: Army Foreign Science and Technology Center, 1986.

Arnoff, Stan. *Geographic Information Systems: A Management Perspective*. Ottawa, Canada: WDL Publications, 1989.

Bellamy, Christopher. *The Future of Land Warfare*. New York: St. Martin's Press, 1987.

_____. *The Evolution of Modern Land Warfare*. London: Routledge, 1990.

Bertalanffy, Ludwig von. *General Systems Theory*. New York: George Braziller, Inc., 1968.

Bond, P.S. *The Engineer in War*. New York: McGraw-Hill Book Company, 1916.

Bond, P.S. *Field Engineering*. Baltimore: The Lord Baltimore Press, 1923.

Clausewitz, Carl Von. *On War*. Edited and translated by Michael Howard and peter Peret. Princeton, NJ: Princeon University Press, 1984.

Coll, Blanch D., Jean E. Keith and Herbert H. Rosenthal. *United States in World War II, The Technical Services: The Corps of Engineers: Troops and Equipment*. Washington D.C.: Office Office of the Chief of Military History, 1958.

Crump, Irving. *Our Army Engineers*. New York: Dodd, Mead & Company, 1954.

Daft, Richard L. *Organization Theory and Design*. New York: West Publishing Company, 1989.

Davis, Franklin M. Jr, and Thomas T. Jones. *The U.S. Army Engineers - Fighting Elite*. New York: Franklin Watts, Inc., 1967.

English, John A. *On Infantry*. New York: Praeger Publishers, 1984.

Frederick the Great. "The Instructions of Frederick the Great to His Generals." Translated by J. D. Hittle in the *Roots of Strategy*, pp. 301-400. Harrisburg, PA: Stackpole Books, 1987.

The Infantry Journal, Inc. *The Corps of Engineers*. Chicago: Rand McNally and Company, 1943.

Jomini, Antoine Henri. "The Art of War." Translated by J. D. Hittle in the *Roots of Strategy, Book II*, pp. 388-557. Harrisburg, PA: Stackpole Books, 1987.

Kegan, John and Richard Holmes. *Soldiers, A History of Men in Battle*. London: Hamish Hamilton Ltd., 1985.

Kelly, Kevin. *Out of Control*. New York: Addison-Wesley, 1994.

Kolibernov, Y.S. *Making of Passages Through the Defenses*. Moscow: Voyenizdat, 1984 (Translated by The Army Foreign Science and Technology Center, 1985).

Kolibernov, Y.S., *Combat Engineer Support*. Moscow: Inzhenernoe Obespecheniye Boya, 1984 (Translated by JPRS-UMA-085-020-L, 26 Aug 1985), (FOUO).

Luthens, Fred. *Organizational Behavior*. New York: McGraw-Hill Book Company, 1989.

Mackenzie, Kenneth D. *Organizational Design: The Organizational Audit and Analysis Technology*. Norwood, New Jersey: Ablex Publishing Corporation, 1986.

Marshall, S.L.A. *Men Against Fire*. Glouchester, MS: Peter Smith, 1978.

Morris, William. *The American Heritage Dictionary*. New York: American Heritage Publishing Company, 1969

Office of History, U.S. Army Corps of Engineers. *Builders and Fighters: U.S. Army Engineers in World War II*. Fort Belvoir VA., 1992.

Sun Tzu. *The Art of War*. Translated by Samuel B. Griffith. New York: Oxford University Press, 1963.

Taylor, Peter J. *Quantitative Methods in Geography*. Prospect Heights, IL: Waveland Press, Inc., 1983.

Toffler, Alvin, and Heidi Toffler. *War and Anti-War: Survival at the Dawn of the 21st Century*. New York: Little, Brown and Company, 1993.

Thompson, Paul W. *The Army Engineers*. New York: W.W. Norton and Company, Inc., 1942.

_____. *Engineers in Battle*. Harrisburg: Military Service Publishing Company, 1942.

_____. *Modern Battle*. New York: Penguin Books, 1942.

Turabian, Kate L. *A Manual for Writers*. Chicago: The University of Chicago Press, 1996.

Periodicals and Articles

Boyd, Morris J., "Force XXI Operations," *Military Review*, November 1994, 17-28.

Fastbend, A. and Ralph H. Graves, "Maneuver, Synchronization and Obstacle Operations." *Military Review*, February 1986, 36-48.

Heslin, John G., "Mobility: Key to Success on the Extended Battlefield." *Military Review*, August 1981, 57-63.

Holder, L.D. and Edwin J. Arnold, "Moving the Heavy Division." *Military Review*, July 1988, 35-49.

Kem, Richard S., J. Richard Capka, and Houng Y. Soo. "E-Force." *Engineer*, Spring 1986, 6-13.

_____. "E-Force an Update." *Engineer*, July 1988, 10-19.

Madigan, James C., MAJ., and Dodge, George E., MAJ., "Battle Command: A Force XXI Imperative," *Military Review*, November 1994, 29-39.

Miller, John E., "Force XXI - Vision for Change," *Military Review*, May-June 1995, 1.

Sullivan, Gordon R., "A Vision for the Future," *Military Review*, May-June 1995, 5-14.

_____. "Land Warfare in the 21st Century," *Military Review*, September 1993, 13-22.

Government Documents, Manuals and Lectures

Arnold, Edwin J., Jr. *American River Crossing Doctrine: A look at Its Compatibility With Current Force Structure and the Modern Battlefield.* Fort Leavenworth, KS: School of Advanced Military Studies Monograph, 1985.

Bales, William J. Combat Engineers: *A Negleted Reconnaissance Asset?* Fort Leavenworth, KS: School of Advanced Military Studies Monograph, 1990.

Benjamin, David J., *An AirLand Battle Challenge: To Cross a River.* Fort Leavenworth, KS: School of Advanced Military Studies Monograph, 1985.

Cababa, Robin R., *Engineer Command/Control Alternatives and Organizational Options at the Maneuver Brigade Level.* Master of Military Arts and Sciences Thesis, U.S. Army Command and General Staff College, 1991.

Carmichael, John M., Maintaining Mobility on a High Tech Battlefield. Ft. Leavenworth KS: School of Advanced Military Studies Monograph, 1989.

Cottrell, Scott D., *Command and Control Relationships and Organization of Engineer Support to the Heavy Division.* Ft. Leavenworth KS: School of Advanced Military Studies Monograph, 1985.

David, William E. David., *Modularity: A Force Design Methodology for the Force XXI Divisional Military Intelligence Battalion.* Ft. Leavenworth KS: School of Advanced Military Studies Monograph, 1996.

Delony, James W., *Tactical mobility and the In-Stride Obstacle Breach: Impossible, Probable or Futuristic?* Ft. Leavenworth KS: School of Advanced Military Studies Monograph, 1988.

Department of the Army. *Field Manual 5-10, The Engineer Platoon (Coordinating Draft).* U.S. Army Engineer School, 1995.

_____. *Field Manual 5-71-2, Task-Force Engineer and Engineer Company Operations (Initial Draft).* U.S. Army Engineer School, 1995.

_____. *Field Manual 5-71-3, Brigade Engineer Combat Operations.* Washington, D.C., 1995.

_____. *Field Manual 5-100, Engineer Operations.* Washington, D.C., November 22, 1988.

_____. *Field Manual 5-103, Survivability*. Washington, D.C., June 10, 1985.

_____. *Field Manual 5-104, General Engineering*. Washington, D.C., November 12, 1986.

_____. *Field Manual 20-32, Mine/Countermine Operations*. Washington, D.C., August 17, 1994.

_____. *Field Manual 25-100, Training the Force*. Washington, D.C., November 15, 1988.

_____. *Field Manual 25-101, Battle Focused Training*. Washington, D.C., September 30, 1990.

_____. *Field Manual 90-7, Combined Arms Obstacle Integration*. Washington, D.C., September 29, 1994.

_____. *Field Manual 90-13-1, Combined Arms Breaching Operations*. Washington, D.C., May 7, 1993.

_____. *Field Manual 5-103, Survivability*. Washington, D.C., June 10, 1985.

_____. *Field Manual 100-2-1, The Soviet Army Operations and Tactics*. Washington, D.C., July 16, 1984.

_____. *Field Manual 100-2-2, The Soviet Army Specialized Warfare and Rear Area Support*. Washington, D.C., July 16, 1984.

_____. *Field Manual 100-63, Infantry-Based Opposing Force Organization Guide*. Washington, D.C., April 18, 1996.

Foreign Broadcast Information Service. *JPRS-UMA-85-020-L, USSR Report - Combat Engineer Support*, August 26, 1985.

Gill, Clair F. et al. *Engineer Directions: AirLand Battle 2000*. Carlisle Barracks, PA: U.S. Army War College Thesis, 1983.

Hildenbrand, Marc R. *The Heavy Division Engineer Regiment - A Key to Tactical Freedom of Action*. Fort Leavenworth, KS: School of Advanced Military Studies Monograph, 1992.

Louisiana Maneuvers Task Force. *Force XXI*, Ft. Monroe, VA., January 1995.

Munch, Paul G., *The Combat Engineer Support to an Offensive Operation*. Master of Military Arts and Sciences Thesis, U.S. Army Command and General Staff College, 1982.

Parr, Anthony. *Soviet Combat Engineer Support*. Garmisch, GE: U.S. Army Institute for Advanced Russian and East European Studies, April 1978.

Pierce, Kerry K., *E-Force: How Agile Is It?* Ft. Leavenworth KS: School of Advanced Military Studies Monograph, 1986.

Romjue, John L. From Active Defense to AirLand Battle: The Development of Army Doctrine 1973-1982. Ft. Monroe, VA: Historical Office, U.S. Army Training and Doctrine Command, June 1984.

Schroedel, Joseph. *Tactical Mobility: Organizing Engineers for an All Arms problem*. Ft. Leavenworth KS: School of Advanced Military Studies Monograph, 1987.

Semonite, Todd T. *What Force Structure Best Positions the Divisional Engineer Bridge Company to Support River Crossing Operations?* Master of Military Arts and Sciences Thesis, U.S. Army Command and General Staff College, 1991.

Sullivan, Gordon R., GEN., *Building the Force for the 21st Century-Force XXI*, Chief of Staff of the Army message dated 8 March 1994.

U.S. Army Armor School. *Operations of the Armored Engineers in the European Theater of Operations*. Ft. Knox, KY. 1950.

_____. *Tactics Techniques and Procedures for the Digitized Company Team*. Ft. Knox, KY., January 1995.

_____. *Tactics and Techniques for the Digitized Battalion Task Force*. Ft. Knox, KY., January 1995.

_____. *Tactics Techniques and Procedures for the Digitized Brigade*. Ft. Knox, KY., February 1995.

U.S. Army Command and General Staff College. *Student Text 20-10: Master of Military Art and Science (MMAS) Research and Thesis*, Ft. Leavenworth, KS., June 1995.

_____. *Student Text 22-2: Writing and Speaking Skills for Senior Leaders*, Ft. Leavenworth, KS., April 1991.

U.S. Army Corps of Engineers Museum. *Genesis of the Corps of Engineers*. Ft. Belvoir VA., 1953.

U.S. Army Engineer School. *Engineer 2000*. Ft. Belvoir, VA. February 1991.

U.S. Army General Board. *Study No. 71 Engineer Organization*. U.S. Forces, European Theater, 1945.

U.S. Army Training and Doctrine Command. *Table of Organization and Equipment 053351000 (Objective), Engineer Battalion, Heavy Division*. Ft. Leonard Wood, Mo., February 2, 1996.

_____.U.S. Army Training and Doctrine Command. *Threat Monograph, A Comparison of Selected NATO and Warsaw Pact Engineer Organizations and equipment*. Ft. Monroe, VA., August 1977.

_____.U.S. Army Training and Doctrine Command. *Threat Monograph, A Comparison of Selected NATO and Warsaw Pact Engineer Organizations and equipment*. Ft. Monroe, VA., August 1979.

_____.U.S. Army Training and Doctrine Command. *TRADOC Pamphlet* 350-17, *Light Opposing Force (OPFOR) Tactics Handbook*, Ft. Monroe, VA., April 14, 1995.

_____.U.S. Army Training and Doctrine Command. *TRADOC Pamphlet 525-5, Force XXI Operations*, Ft. Monroe, VA., August 1994.

_____.U.S. Army Training and Doctrine Command. *TRADOC Pamphlet 525-68, Concept for Modularity*, Ft. Monroe, VA., January 1995.

_____.U.S. Army Training and Doctrine Command. *TRADOC Pamphlet 525-XX, Concept for Information Operations (Coordinating Draft)*, Ft. Monroe, VA., February 1994.

_____. *TRADOC Pamphlet 525-XX, Force XXI Division Operations Concept (Draft)*, Ft. Monroe, VA., February 7, 1995.

U.S. Army Training and Doctrine Command Analysis Center. Study Plan TRAC-SP-November 1995, Force XXI Division Redesign Analysis.

Walker, Paul K. *Engineers of Independence*. Washington, D.C.: Office of the Chief of Engineers. Undated.

Wells, Gordon M., *U.S. Army River Crossing Doctrine and AirLand Battle Future*. Ft. Leavenworth KS: School of Advanced Military Studies Monograph, 1990.

Wilson, Michael T., *Tactical Survivability: The Engineer Delima*. Fort Leavenworth, KS: School of Advanced Military Studies Monograph, 1987.

Software

Microsoft Corporation. *Microsoft Office 4.3*, Redmond WA, 1994.

Evolution Computing. *EasyCAD 2*. Tempe, AZ, 1989.